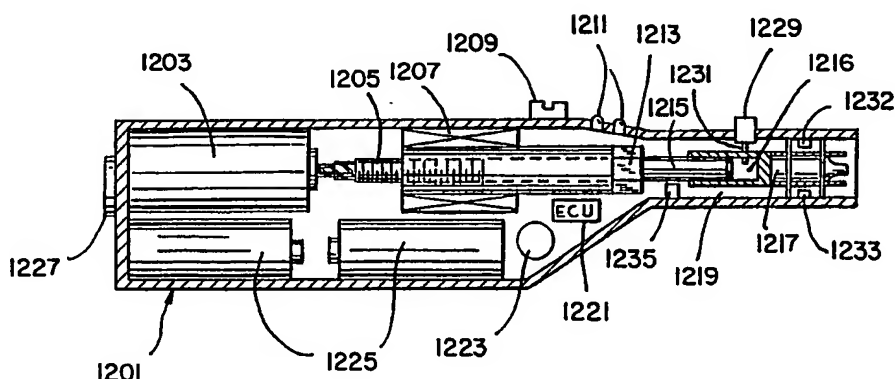




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(54) Title: MEDICAMENT INJECTOR AND METHOD

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An automatic programmable portable injection/aspiration device and injection cartridges used therewith are provided for administration of medicaments. The device includes a chamber (1219) configured for the receipt of a prepack-aged disposable medicine cartridge (1217), means (1215) for operating the cartridge, means (1221) for controlling the rate, direction and extent of needle insertion, fluid injection and needle withdrawal. Means (1221) for storing data and for programming the device to predetermine and vary the rates as desired, and sensors (1233, 1235) and indicators (1211) for detecting and indicating various rates and parameters of performance are also provided. Also provided are means (1232) for automatically interrogating an injection site to insure that the site is medically appropriate and locking means (1229) for preventing accidental discharge of the device. Injection cartridges (1217) adapted for storing and injecting single- or multiple-component medicaments are provided for use with the device, or for manual use or with mechanical actuators (1203, 1205, 1207).

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## MEDICAMENT INJECTOR AND METHOD

### Background of the Invention

The present invention relates to an injection/aspiration device and a cartridge vial for use therewith for medical and research purposes and more particularly to a device designed for injecting medicines and other fluids into human beings and other subjects using a hollow injection needle. Both the injection/aspiration and cartridge vial components of the invention are also configured to aspirate blood and/or other fluids.

In the conventional medical procedure for injecting medicines or for aspirating blood or fluids, a syringe with a hollow injection/aspiration needle, such as a standard hypodermic needle, is used. Needles are repugnant to many patients, particularly those who must have regular injections of medicine or blood samples taken. Among these are elderly patients and people who must have daily injections of insulin or other drugs. Similarly, pediatric patients are particularly afraid of needles. Exposed or visible needles are undesirable because they create fear and apprehension in many subjects.

Another problem in the medical field is that of the communication of infectious diseases caused by used needles and syringes and fluids therefrom coming into contact with doctors, nurses, or other medical personnel. Needle tips often remain exposed after aspiration of a fluid or blood from a subject, or after injection of a medicine into a subject and medical personnel are sometimes accidentally pricked with such tips. This problem is particularly acute in situations where a syringe and needle have been contaminated with particularly virulent organisms such as the AIDS virus or

the hepatitis virus. The risk of puncture with a contaminated needle point is of particular concern after an injection because a finger, hand or other part of the person administering the injection is typically in close physical proximity to the needle during its removal from the subject's tissues, during replacement of a needle or the needle cover or during removal of the needle from a syringe for disposal.

There is also danger of such exposures to personnel, such as maintenance people, other than medical personnel, when a used needle and/or syringe is laid aside or discarded with a needle tip still exposed. This danger continues even when a used needle and/or syringe are placed in a disposal container. For instance, it is a routine medical procedure to use a device which cuts off the tip of an exposed needle so that it may not be re-used. However, this procedure still leaves exposed needle stubs and syringe parts which may be contaminated with infectious agents and with which persons may come into contact and be infected. Thus, it is not uncommon for discarded needle stubs to protrude through plastic garbage bags or other containers and present serious risk of a puncture wound to a person handling or otherwise coming into contact with the container. Similarly, even after used needles are removed from syringes and placed in sealed containers, the exposed syringes must also be placed in sealed containers to reduce the likelihood of infectious contact with personnel. Sanitary disposal of used needles and used syringes is an expensive and time consuming process and entails significant risk of exposure to infectious disease vectors.

A related problem is that of the dangers of exposing a needle to the atmosphere prior to its being used in giving an injection or withdrawing a body fluid. Not only is there danger of wounds to user personnel and patients from the exposed needle tip, but also there is the danger that the exposed needle will become contaminated by



airborne or aerosol borne microbial and other contaminants and infect the patient eventually injected. This danger is particularly acute in hospitals and other medical treatment areas where strains of antibiotic-resistant microbes endemically contaminate the air and all exposed surfaces. Contact with non-sterile air is a certainty with conventional exposed needle syringe technology because, in this technology, needles are routinely exposed to the air or surfaces for some discrete amount of time during use. Also, in emergency use situations such as military combat, natural disasters, or industrial accidents, the unused needle may be left exposed to such contaminants by untrained, harried or inexperienced personnel.

Yet another common problem in conventional syringe/injection technology is that relating to improperly given injections. The differences in the rate which a needle must travel during insertion into and withdrawal from the subject's tissues and the rate at which a syringe piston must be operated in order to inject or aspirate fluid in a painless manner are substantial. The techniques of various medical personnel in using conventional syringes are varied. Techniques vary according to the position of the subject, how that portion of the subject's anatomy which is to be injected is held, and by the various individual techniques of medical personnel. This problem is particularly acute with respect to untrained or inexperienced personnel. When a needle is inserted too slowly, needless pain results. These problems are overwhelmingly due to the difficulty of operating a syringe and needle in a manner which appropriately varies the rates of needle insertion and withdrawal and the rates of fluid injection and aspiration.

An additional problem in the field is that of dosage management. For subjects who give themselves injections, either because they require regular doses of injected

pharmaceuticals or because medical personnel are not available, it is critical to insure that dosages are correct. Diabetic subjects often find themselves in such situations, particularly diabetics who suffer from the related condition of blindness. Other blind people are similarly in need of a product which insures that both the type of medication and its dosage are correct for their specific needs. Similarly, soldiers in the field, travelers requiring regular injectable medications, and subjects in emergency situations where self-injection is necessary often have difficulty administering the proper dosage of a given drug and often have difficulty in using a conventional syringe. Such problems are also compounded by darkness or poor lighting conditions in battlefield, power failure, and other crisis or emergency situations.

It is well known in the medical injection field that, when administering a drug or other substance intramuscularly, an attempt is made to aspirate blood or other physiological fluid after insertion of the injection needle into a site thought to be suitable. Such an attempted aspiration is made in order to interrogate the injection site (i.e., essentially, as understood in the art the volume of tissue immediately adjacent to and in fluid communication with the open end of the needle) for the presence of blood, lymph, cerebrospinal fluid, or the like. This interrogation is made to insure that pharmaceutical substances or other fluids are not unintentionally injected inappropriately, e.g., into a blood vessel, lymph vessel or into cerebrospinal fluid. The inappropriate administration of a drug or other substance into a blood vessel, lymph vessel or cerebrospinal cavity could result in any of a number of adverse effects including nausea, unwanted toxicity, paralysis, neurological damage or even death. Moreover, the administration of pharmaceutical substances to inappropriate sites often results in attenuation or loss of the substance's desired, specific functional

characteristics or activities. Thus, it is of paramount importance to insure that a needle used in administering a drug or other substance be inserted into an appropriate injection site.

5           For subjects injecting themselves at home, in emergency situations, or in combat, it is virtually impossible to perform the correct procedure. Similarly, personnel who are untrained in medical injection procedures but must give injections because of crisis or  
10 emergency situations are much more likely to incorrectly administer a substance, either by administering an incorrect dosage or administering by placing the needle so that its tip is positioned at an inappropriate site (e.g., so that the substance is injected directly into  
15 the blood stream rather than intramuscularly).

          An example where a pharmaceutical substance must be delivered to an exact site is in the administration of certain chemotherapeutic drugs for the treatment of cancer. It is absolutely necessary that chemotherapeutic  
20 drugs be delivered to the exact target tissue. Exposure of some of these drugs to the skin or to the incorrect tissue or to the bloodstream may cause severe side effects. It is thus desirable to have a means for automatically interrogating the fluids in an injection  
25 device to insure that blood or other physiological fluids are not being inappropriately aspirated from a possible injection site into the device before drug is administered with the device. Thus, it would also be desirable to have a device which will automatically pre-  
30 vent injection of pharmaceuticals at an undesirable or inappropriate injection site. In other cases, however, it might be desirable or necessary to inject a drug into, for example, the bloodstream; then the interrogation would be to assure that a physiological fluid, such as  
35 blood, is aspirated into the injection device before using it to inject the drug.

The present invention also relates to a two-component safety injection syringe for medical and research purposes and more particularly to a device designed to separately store a medicament and a solvent therefor until a time just prior to injection when the two substances are mixed and then injected.

It is well known in the medical field that the shelf life of particular pharmaceutically or medically active substances is increased when the active substance is stored in a dry form or in stable but non-injectable solution form prior to injection. Many drugs now being marketed or being developed for marketing are not stable in their deliverable solutions for a sufficient period of time to allow for commercial distribution or have shelf lives which are unacceptably short. Among these pharmaceuticals are epinephrine, which is used to treat severe allergic and anaphylactic reactions, and cyclophosphamide, an anti-cancer substance. Other pharmaceutically active substances such as urokinase, which is used for dissolving blood clots, and glucagon, which is used for treating hypoglycemia, are stable only in dry powder forms. Papaverine, which is optimally stored in solution at very acidic pH levels (in the range 2.0 - 2.8) must be mixed with a physiologically acceptable solvent immediately prior to injection to avoid the painful and destructive effects associated with acidic solutions. Other medically active substances which do not store well in forms which can be easily administered are adenosine triphosphate (available from Genentech) and Prostaglandin-E which has a shelf life of only 24 hours when mixed for infusion.

However, storage of a medically active substance in a stable non-injectable form necessitates the pre-injection mixing of the substance with a medically acceptable solvent. Therefore, separate containers for solvent and solute are generally used. However, this method of pre-injection mixing is inconvenient because it

requires more than one container. The use of more than one container is also undesirable because judgement on the part of the person mixing the medication is required to use amounts which result in an appropriate dosage and  
5 also because of the problems surrounding the difficulties in maintaining sterility when materials from two or more separate containers are mixed.

Thus, it can be seen that a need exists for injection devices which increase the shelf-life of particular  
10 pharmaceuticals by separately storing the various components of certain medicaments for a commercially acceptable period of time until a time just prior to injection. A related need is for devices which increase those shelf-lives and which require a minimum of  
15 preparation to insure a dependable and correct dosage administration. The fulfillment of such need will permit the commercial availability of many pharmaceuticals which have been heretofore available only directly from professional medical personnel.

20 In an attempt to solve these problems, a number of wet-dry syringes which incorporate both solvent and medically active solute in the same cartridge to be mixed just prior to injection have been developed. U.S. Patent 4,689,042 to Sarnoff et al. shows a two-barreled syringe  
25 wherein the solid medicament and liquid solvent are stored in separate container portions of the device. Pre-injection mixing and injection in Sarnoff are controlled by a number of biasing springs which sequentially operate by way of releasing mechanisms to propel the solvent from  
30 one compartment into a dry medicament-containing compartment via communicating passages. The entire apparatus is then agitated by the operator to mix the medicament and solvent prior to the injection. The operator then places the injection needle into target  
35 tissue and actuates an injection mechanism which propels the mixed medicament into the subject. Sarnoff is a

complex mechanism employing many components and requiring several discrete operating steps to use.

Similarly, U.S. Patent 4,755,169, also to Sarnoff et al. discloses a multi-compartmented stacked syringe-  
5 within-a-syringe assembly wherein a biasing spring propels a mixing/injection piston and primary needle to rupture a seal between the respective medicament component compartments of the device. After agitation of the device and insertion of the injection needle into a  
10 target site by the operator, the biasing spring is again actuated to drive a second piston which propels the mixed medicament into the subject. Although somewhat simpler than the device of the '042 Sarnoff patent, the invention of the '169 patent is also a complex mechanism employing  
15 many components and requiring several discrete operating steps to use.

U.S. Patent 4,328,802 to Curley et al. discloses a wet-dry syringe and connected vial which are separated during use and wherein the piston portion of the syringe,  
20 being biased by a spring, is actuated to inject the solvent into the solute vial whereby mixing occurs. Manual aspiration into the syringe is then necessitated to charge the syringe with the mixed medicament/solvent solution. Removal of the syringe portion from the  
25 syringe/vial assembly is required prior to injection into the subject.

Other two-chambered syringes are marketed under the tradename Variject, manufactured by Bunder Glas GmbH. The Bunder device is a single cylinder syringe wherein a  
30 fluid bypass allows mixing of the medicament solvent and medicament during operation of the device.

The multiple piston assemblies of the aforementioned devices are mechanically complex and expensive to manufacture. In addition, none of the aforementioned  
35 devices provides for the withdrawal of the used injection needle to reside completely within the device to afford safe disposal and disease prevention characteristics.

Thus, it can be clearly seen that there is a need for injection devices which contain pre-measured dosages of particular pharmaceutical substances wherein the administration or self-administration of those doses can be easily and dependably achieved by non-professional personnel. It can also be clearly seen that a need exists for injection devices which can be operated manually, or by mechanical means such as spring tension or gas pressure, or which can be operated automatically by means of electronic or other data processing means.

#### Summary and Objects of the Invention

It is an object of the present invention to provide concealment of an injection needle at all stages of use, thereby reducing the apprehension of the patient.

It is similarly an object of the present invention to maintain sterility of an injection needle at all stages of use by providing means whereby the needle, prior to contact with the skin of a patient for penetration therethrough, is never exposed to any potentially contaminating surfaces, aerosols or airborne particles or microbes.

It is another object of the present invention to provide an injection vial which eliminates the dangers of infection or injury resulting from accidental contact with exposed needles.

It is still another object of the present invention to provide a sanitarily disposable injection vial with a needle which, after use in an injection, retracts completely into said vial to reduce the risk of disease transmission caused by the risk of exposure to a contaminated needle or to a contaminated syringe or to parts thereof.

It is yet another object of the present invention to provide a sanitarily disposable injection vial which can be safely discarded without the need for special

equipment or containers and which can be safely and sanitarily disposed of in non-hospital, rugged, or emergency environments.

5 It is also an object of the present invention to provide an ampule or cartridge for dispensing fluid medication which can be filled by the use of conventional pharmaceutical packaging machinery, thus avoiding the substantial expense which would be required for the development and production of non-conventional packaging  
10 methods and machinery.

It is a further object of the present invention to reduce the risk of an improperly administered injection by providing means for precisely, automatically, and programmably controlling the rate of needle insertion,  
15 the rate of needle withdrawal, the rate of medicine injection, and the rate of fluid aspiration.

It is also an object of the present invention to reduce the risk that an incorrect dosage of a fluid medicine will be administered by injection.

20 It is a further object of the invention to reduce the risk that an incorrect drug will be administered to a subject or be self-administered by a subject.

It is an object of the present invention to provide means for the automatic interrogation of an injection  
25 site to determine whether or not the injection needle tip is at an appropriate or desired site and in the desired target tissue.

It is a further object of the present invention to provide means for automatically scanning an  
30 injection/aspiration cartridge during operation to determine if blood or other physiological fluids have been aspirated from an actual or possible injection site into the cartridge.

It is also an object of the present invention to  
35 provide means for automatically preventing the injection of medicines or other fluids into an undesired or inappropriate tissue or site.



Furthermore, it is an object of the present invention to provide means to administer a drug to a pre-selected target tissue and avoid exposure of the drug to tissues which would be undesirably damaged by such exposure.

5 It is yet another object of the present invention to provide a means for giving or self-administering penile injections of drugs with a minimum of pain and apprehension on the part of the male.

10 It is an object of the present invention to provide a simplified syringe for the separate storage and pre-injection mixing of a medically active substance and a physiologically acceptable solvent or fluid.

15 Another object of the present invention is to provide a disposable safety syringe adapted to be used manually or with an automatic injector for the separate storage and pre-injection mixing of a medically active substance and a physiologically acceptable solvent or fluid.

20 It is a similar object of the present invention to provide a syringe adapted for the pre-injection mixing of at least one liquid component with another component which has the safety feature of an injection needle which withdraws after use to reside completely within the closed cartridge, thus reducing the dangers of infection or injury resulting from accidental contact with exposed  
25 needles.

It is an additional object of the present invention to provide a cartridge syringe with means for automatically mixing medicament components immediately prior to injection.

30 It is yet another object of the present invention to provide a needle assembly housing which can be used with necked medicament containers of both conventional and non-conventional types.

35 In accordance with the objectives of the invention, a vial for fluid injection is provided. The injection vial is a double-ended cartridge, having a first end and a second end, the cartridge having a cylindrical bore

defined by a wall extending between the first end and the second end, the bore being suitable for storing a fluid charge to be expelled therefrom. A first piston and a second piston are positioned within the bore and are  
5 slidably seated against the cylindrical wall of the bore, the first piston comprising means for reversibly engaging a plunger. The cartridge is provided with a puncturable end cap which is rigidly attached and sealed to the second end of the cartridge and which comprises a needle  
10 guide. The cartridge is also provided with a hollow injection needle having an external tip and an internal tip, the internal tip being rigidly attached to and passing through the second piston, and the external tip extending toward the end cap without protruding  
15 therefrom, and means for locking the first piston and the second piston irreversibly together when the first piston and the second piston are a predetermined distance apart. It is preferred that the puncturable end cap be made of a self-sealing material, although this is not  
20 necessary for practicing the invention.

The vial may also be provided with a readable indicator to indicate the type of medication, patient information, the amount of medicine to be injected and the various rates of needle insertion and withdrawal and  
25 of fluid injection and/or aspiration.

In accordance with another aspect of the invention, a programmable automatic injection/aspiration device is provided having a housing, a chamber disposed within the housing for reversibly receiving a cartridge vial, and a  
30 cartridge vial piston operating plunger slidably disposed within the housing. Also provided are means, disposed within the housing, for propelling the plunger. Similarly, controller means for controlling the rate, direction, and extent of movement of the plunger are  
35 provided. Control is thus provided via said propelling means, and a programmable processor for directing the controller, a sensor for detecting the rate, direction,

and extent of movement of the plunger, an indicator for indicating the rate, direction, and extent of movement of the plunger and for indicating the amount of fluid remaining and expelled from a fluid vial, and a sensor  
5 for detecting the presence in the vial of aspirated physiological fluids are also provided. Similarly provided are means for automatically preventing injection into an undesirable target tissue upon the detection of aspirated physiological fluid, and locking means for  
10 preventing unintentional discharge of drug from a cartridge vial disposed in the injection/aspiration device.

In accordance with the invention, a cartridge vial, containing a fluid medicine charge, may be inserted into  
15 an injection/aspiration device, which may then be used to administer the medicine by injection. Finally, the cartridge vial, with completely retracted needle, may be removed and discarded, while the injection/aspiration device may be repeatedly re-used with different cartridge  
20 vials.

In accordance with other objects of the invention, a mixing syringe for two-component medicaments is provided. The mixing syringe has a cartridge housing having a first end and a second end, a substantially  
25 cylindrical cartridge housing bore, a slidable cartridge disposed in the cartridge housing bore having a first end, a second end, and a temporary sealing barrier disposed between the first and second ends separating the bore of the cartridge into a cylindrical medicament  
30 solvent charge chamber and a cylindrical medicament charge chamber.

The cartridge housing is also provided with means, fixedly attached thereto, for breaching the temporary sealing barrier, the cartridge being suitable for  
35 separately storing a medicament solvent charge and a medicament charge in the medicament solvent charge chamber and the medicament charge chamber, respectively,

the charges to be mixed to form a medicament to be expelled from the cartridge.

A piston is disposed within the first end of the cartridge and is slidably seated in the cartridge bore.

5 A retractable needle housing assembly is slidably disposed in the cartridge housing and a retractable injection needle is provided fixedly attached to the needle housing assembly and extending therethrough for injecting mixed medicament. A puncturable cartridge end

10 stopper is provided rigidly attached to and sealing the second end of the cartridge. In some embodiments of the invention, a puncturable end cap, the end cap sealing the second end of the cartridge housing and having a needle guide disposed therein is provided.

15 Further in accordance with the objects of the invention, an operating shaft for operating the piston and the cartridge and for adapting the cartridge to other devices is provided in the piston. The operating shaft may be provided with a chamber for receiving a pushrod or

20 injection needle portion which has punctured the piston therethrough. In some embodiments of the invention, the breachable temporary sealing barrier is so configured that the piston can pass sealably therethrough after the barrier is breached. In accordance with this aspect of

25 the invention, various valves, having substantially cylindrical openings which permit the piston of the cartridge to pass therethrough, are provided. These valves include but are not limited to stopcocks, membranes and seats therefor, iris valves, and ball and

30 seat valves.

In accordance with additional objects of the invention, a needle housing assembly for use with necked medicament containers which have puncturable end stoppers is provided. The assembly is provided with a needle

35 housing, locking means disposed in the needle housing for locking the housing to the necked medicament container when the needle housing assembly and the necked cartridge

become a predetermined distance apart upon relative movement between the necked medicament container and the needle housing, and an injection needle.

5       The injection needle is provided with a hollow shaft, an internal end, an internal shaft portion, an external end, an external shaft portion, first and second apertures, and a passageway extending through the hollow shaft and connecting the first and second apertures, the needle being rigidly attached to and extending through  
10       the needle housing, the internal end and internal shaft portion of the needle being adapted to puncture a necked medicament container, and the external end and external shaft portion of the needle being adapted to expel a medicament out of the needle housing assembly.

15       The means for locking the housing to a necked medicament container, a needle assembly housing, comprises protrusions which are disposed in the housing and which are adapted to securely engage the neck and head portions of a medicament container. In a preferred  
20       embodiment, the needle assembly housing is provided with flanges which are disposed to capture and securely hold the neck and end portions of a necked medicament container of either a conventional or non-conventional type. The needle assembly housing of the present  
25       invention is adapted to facilitate reduced inflammation at an injection site by being configured to insure that the injection needle is inserted into the target tissue before the medicament is injected.

30       The needle assembly housing of the present invention is adapted to be used within a cartridge housing of an automatic or non-automatic injection device having an expansion chamber which permits expansion of the needle assembly housing flanges in conjunction with a slidable cartridge for the capture thereof. It is also clear that  
35       the needle assembly housing of the present invention can be adapted to be used independently with various necked

medicament containers which are used without an injector device.

5 In accordance with yet other embodiments of the invention, the means fixedly attached to the cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises a spiral pushrod having an anchoring end and a puncturing end suitable for engaging the operating slot of a rotor valve, the anchoring end being provided fixedly attached to the cartridge housing and the spiral pushrod extending from the cartridge housing toward the cartridge puncturable end stopper, through a pushrod aperture provided in a needle assembly housing for freely guiding the pushrod therethrough so that the puncturing end of the pushrod resides in close proximity to and in alignment with the puncturable cartridge end stopper. In an additional embodiment of the invention, the spiral pushrod is adapted to operate a mixing rotor provided in the cartridge for agitating the solvent/solute mixture as it passes through the cartridge to be expelled therefrom.

20 In accordance with still further objects of the invention, a mixing syringe for two-component medicaments is provided comprising a cartridge housing having a first end and a second end, the cartridge housing having a substantially cylindrical cartridge housing bore, a slidable cartridge disposed in the cartridge housing bore and having a first end, a second end, and a temporary sealing barrier disposed between the first and second ends and separating a cartridge bore of the cartridge into a cylindrical medicament solvent charge chamber and a cylindrical medicament charge chamber, the cartridge housing having means, fixedly attached thereto, for breaching the temporary sealing barrier, and being suitable for separately storing a medicament solvent charge and a medicament charge in the medicament solvent charge chamber and the medicament charge chamber,

respectively, the charges to be mixed to form a medicament to be expelled from the cartridge.

5 The cartridge is also provided with a piston disposed within the first end of the cartridge and being slidably seated in the cartridge bore, and a needle housing assembly rigidly attached to the cartridge and contained wholly within the cartridge housing. Also provide is an injection needle which is containable wholly within the cartridge housing, which can be extended to a position in 10 which at least a portion of the needle extends outside of the cartridge housing, the needle being fixedly attached to the needle housing assembly and extending therethrough for injecting mixed medicament. The cartridge is also provided with a puncturable end cap, the end cap sealing 15 the second end of the cartridge housing, and means for retracting the needle to reside completely within the cartridge housing after the expulsion of the medicament from the syringe is completed. The breachable temporary sealing barrier is so configured that the piston can pass 20 sealably therethrough after the barrier is breached being provided with a cylindrical bore of substantially equal dimension to that of the cartridge bore so that the piston can pass sealably therethrough after the barrier is breached. The barrier can be a valve disposed through 25 the cartridge having an operating cam disposed on the exterior of the cartridge wherein the valve operating cam is configured to be operated by a pushrod integral to the cartridge housing.

30 Yet further in accordance with the objects of the invention are provided an electronically or magnetically actuated pushrod contained within the cartridge and an electronic or magnetic pushrod actuator contained within the cartridge housing for breaching the temporary seal between chambers of the slidable cartridge.

35 Yet still further in accordance with additional objects of the invention, a mixing syringe is provided for the pre-injection mixing of two-component medicaments

which comprises a cartridge housing having a first end and a second end, the cartridge housing having a substantially cylindrical cartridge housing bore and a slidable cartridge disposed in the cartridge housing bore having a first end, a second end, and a temporary sealing barrier disposed between the first and second ends and separating the cartridge bore into a cylindrical medicament solvent charge chamber and a cylindrical medicament charge chamber, the cartridge being suitable for separately storing a medicament solvent charge and a medicament charge in the medicament solvent charge chamber and the medicament charge chamber, respectively, the charges to be mixed to form a medicament to be expelled from the cartridge. The cartridge is provided with a piston disposed within the first end of the cartridge and being slidably seated in the cartridge bore and a retractable needle housing assembly slidable in the cartridge housing the needle housing having means, fixedly attached thereto, for breaching the temporary sealing barrier. The device is further provided with a retractable injection needle having a hollow shaft, an internal end, an internal shaft portion, an external end, an external shaft portion, first and second apertures, and a passageway extending through the hollow shaft and connecting the first and second apertures. The needle is rigidly attached to and extends through the needle housing, the internal end and internal shaft portion of the needle being adapted to puncture the cartridge, and the external end and external shaft portion of the needle being adapted to expel a medicament out of the needle housing assembly, the first injection needle aperture being disposed in the internal needle shaft portion an appropriate distance from the housing to receive fluid from a punctured medicament cartridge, and the second injection needle aperture being disposed in the external needle end.



### Brief Description of the Drawings

The invention will now be described with reference to the enclosed drawings, in which:

5 Figure 1 is a sectional elevation view of a cartridge syringe constructed in accordance with a first embodiment of the present invention which utilizes a plug as a means for separating the chambers of the cartridge.

10 Figures 2(a) and 2(b)-2(e) are sectional elevation views of a cartridge syringe constructed in accordance with a second embodiment of the present invention which utilizes a burstable membrane as a means for separating the chambers of the cartridge and which utilizes an elution column for storage of the medicament solute.

15 Figures 3(a) and 3(b)-3(d) are sectional elevation views of a cartridge syringe constructed in accordance with another embodiment of the present invention wherein the means for separating the chambers of the invention is a rotary valve operated by a spiral twist rod.

20 Figures 4(a) and 4(b)-4(d) are sectional elevation views of a cartridge syringe constructed in accordance with another embodiment of the present invention wherein the means for separating the chambers is a stopcock extending through the cartridge which is actuated by a pushrod and wherein means for automatically agitating the  
25 components of the medicament during operation is provided.

30 Figures 5(a) and 5(b)-5(e) are sectional elevation views of a cartridge syringe constructed in accordance with another embodiment of the present invention wherein a stopcock barrier means is actuated by a pushrod integral to the cartridge housing and wherein the medicament solute is disposed in a mixing maze through which the medicament solvent must flow.

35 Figures 6(a)-6(c) are sectional elevation views of a cartridge syringe constructed in accordance with yet another embodiment of the present invention wherein a

burstable membrane barrier is breached by an electronically or magnetically activated means and wherein the injection needle is fixedly attached to the cartridge.

5        Figure 7 is a sectional elevation view of a cartridge syringe constructed in accordance with another embodiment of the invention similar to that shown in Figure 1 but wherein the extended injection needle also performs the barrier breaching function of a pushrod.

10       Figure 8(a) is a perspective view of an embodiment of the needle housing assembly constructed in accordance the invention which can be used with various necked containers known in the art as well as with various embodiments of the cartridge syringe of the present invention.

15       Figure 8(b) is a plan view of the needle housing assembly of Figure 8(a).

      Figure 8(c) is sectional view taken along the lines A-A in Figure 8(c).

20       Figure 8(d) is an enlarged view of Detail A of Figure 8(c).

      Figure 9(a) is a sectional elevation view of a cartridge syringe constructed in accordance with the present invention similar to that shown in Figures 5(a)-  
25       (e) but wherein a spherical ball valve having an aperture suitably configured for the passage therethrough of the piston and a solute is disposed on a grid in the necked portion to permit substantially complete evacuation of the cartridge are provided.

30       Figure 9(b) is a detail view of the ball valve operating cam in the closed position of Figure 9(a).

      Figure 9(c) is a sectional elevation view of the cartridge of Figure 9(a) wherein the ball valve has been opened and the piston has passed sealably therethrough to  
35       evacuated the solvent/solute mixture and to become seated at the curved abutments forming the necked portion of the cartridge.

Figure 9(d) is a detail view of the ball valve operating cam in the open position of Figure 9(c).

Figure 10 is a longitudinal cross-sectional view of an injection/aspiration device showing the relative placement of the cartridge vial and other components;

Figure 11 is a longitudinal cross-sectional view of a cartridge vial constructed in accordance with an embodiment of the invention suitable for storing and injecting a single solution medicament;

Figure 12 illustrates another embodiment of a cartridge vial suitable for the storage and injection of a single solution medicament wherein a slidable ampule functions similarly to the first piston of the embodiment shown in Figure 11 and alternate means for needle retraction are provided which ampule can be manufactured using conventional pharmaceutical packaging machinery.

Figure 13 illustrates an additional embodiment of the cartridge vial similar to that shown in Figure 12 but for the storage and injection only of a single component medicament and wherein certain dimensional relationships are varied.

#### Detailed Description of the Preferred Embodiments

The advantages and characteristics of the cartridge mixing syringe and needle housing of the present invention can be elucidated from the following detailed description of several embodiments of the mixing syringe and needle assembly to be taken as examples and not as limitations in conjunction with the accompanying drawings.

From the information herein, it is also clear that many permutations of the present invention other than those shown in the drawings are possible by the combination of components from the various embodiments. For example the needle assembly housing and cartridge housing shown in Figure 2 could, with slight

modification, be adapted to utilize the magnetically or electronically actuated burstable membrane components shown in Figure 6.

With reference to Figure 1, a two-component cartridge mixing syringe comprises a double ended circularly cylindrical cartridge housing 1 constructed of a rigid material such as polyethylene and having a cartridge residence chamber 15 and a needle housing residence chamber 2 and needle housing assembly receiving chamber 11. Cartridge housing 1 is provided with a puncturable sealing end cap 3 of resilient material such as butyl rubber, a plastic needle guide 5 rigidly embedded in end cap 3 and having a needle guide aperture 7 formed therein and an injection device positioning projection 9. End cap 3 is also provided with a pushrod 60 anchored to 34 needle guide 5 at pushrod anchoring end 66 and constructed of a suitable material such as stainless steel. Pushrod 60 extends through a needle assembly housing pushrod aperture 20 toward a puncturable cartridge end stopper 39. Needle housing assembly receiving chamber 11 is further provided with curved abutments 13 of appropriate configuration to allow a needle assembly housing 18 to both enter and withdraw from needle assembly housing receiving chamber 11. Needle assembly housing 18 and a cylindrical cartridge 31 are initially disposed within needle housing residence chamber 2 and cartridge residence chamber 15, respectively.

Cylindrical cartridge 31 is constructed of a rigid material such as Lexan plastic, is slidably positioned within cartridge housing 1 and is provided with a three-portion chamber in which is stored a solvent charge 51 and a solute charge 63. Solvent charge 51 is stored in a first portion 33 of cartridge 31. Solvent charge 51 can consist of a single solvent or diluent, mixed solvents or diluents, a concentrated solution or one or more parts of a multiple-part medically active substance

or system. First portion 33 is separated from a second cartridge solute storage portion 35 by a plug seat 62 which is rigidly affixed to the internal walls of cartridge 31 and a plug 61.

5           Second cartridge solute storage portion 35 has stored therein solute charge 63 in finely divided form on a puncturable high-surface-area solute trait grid 64. Solute charge 63 can consist of solid medicament, liquid medicament, a diluent for a concentrated solvent or one  
10 or more parts of a multiple-part substance or system. Solute charge 63 is disposed across second cartridge solute storage portion 35 so that solvent charge 51 moves through grid 64 thus dissolving solute charge 63 before the mixed solute/solvent is expelled through a hollow  
15 injection needle 23. A third cartridge injection needle portion 37 is provided with a puncturable cartridge end stopper 39 of a resilient material within a cartridge cap 38. A cartridge piston chamber abutment 40 forms a transition between second cartridge storage portion 35  
20 and third cartridge injection needle portion 37 and forms a seat for solute tray grid 64. The external portion of the transition between third cartridge portion 37 and cartridge cap 38 forms a cartridge shoulder 41. Cartridge shoulder 41 functions as a flange engaging step for  
25 engaging flanges 19 of needle assembly housing 18 during operation of the invention.

Cartridge 31 is further provided with a piston 45 of a resilient material and having a piston shaft 47 and a piston shaft head 49 for reversibly engaging an  
30 injection/aspiration device or an adapter for manual operation. Such a cartridge could be engaged to an injection/aspiration device or manual adapter by any other means, other than a piston similar to piston 45 as shown, such as a T-shaft and keyway, a threaded rod,  
35 piston engaging barbs, or other means providing secure engagement of a cartridge to an injection/aspiration

device. It is preferred that the means for engaging be reversible.

Needle assembly housing 18 is of a rigid material such as linear polypropylene and is provided with a  
5 needle assembly housing bottom 16, needle housing walls 17, needle assembly housing flanges 19 and needle assembly housing lips 21 disposed for securely engaging cartridge 31. Needle assembly housing 18 is also provided with a needle assembly housing pushrod aperture  
10 20 having sharpened stainless steel pushrod 60 passing therethrough. Needle assembly housing 18 is further provided with the hollow injection needle 23 which is rigidly attached to housing 18 and which passes therethrough. Injection needle 23 has an internal tip 25  
15 disposed toward puncturable cartridge stopper 39 and an external tip 27 for selective movement out of the housing and insertion into target tissue which passes through aperture 7 of needle guide 5 but does not protrude through sealing end cap 3 until operation of the  
20 invention.

The relative lengths of needle assembly housing walls 17, needle assembly housing receiving chamber 11, and pushrod 60 are such that, in operation of the device as described hereinbelow, a pushrod puncturing end 68 of  
25 pushrod 60 penetrates puncturable cartridge end stopper 39 and dislodges plug 61 from plug seat 62 before needle internal end 25 contacts puncturable cartridge end stopper 39. Third cartridge injection needle portion 37 is captured by the engagement of needle assembly housing  
30 flange lips 21 by cartridge shoulder 41 of cartridge 31 when cartridge 31 has been propelled a sufficient distance toward puncturable cartridge sealing end cap 3 that needle assembly housing 18 is fully within needle assembly housing receiving chamber 11.

35 The above-described embodiment of the mixing syringe operates as described hereinbelow.

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Piston 45 is propelled toward sealable end cap 3 by the application of force to plunger shaft head 49 in the direction of sealing end cap 3, which force is communicated through plunger shaft 47 to piston 45 thus  
5 applying hydraulic pressure through solvent charge 51, plug 61 and plug seat 62, and forcing cartridge 31 and needle assembly housing 17 having injection needle 23 fixedly attached therethrough toward sealing end cap 3, this action simultaneously forces cartridge 31 onto  
10 pushrod end 68, which slides freely through needle assembly housing pushrod aperture 20, thus also propelling injection needle 23 through needle guide aperture 7 causing external needle tip 27 to puncture puncturable sealing end cap 3. The relative lengths of  
15 needle assembly housing walls 17 needle assembly housing receiving chamber 11 and pushrod 60 are such that pushrod puncturing end 68 penetrates puncturable cartridge end stopper 39 and dislodges plug 61 from plug seat 62 thus causing solvent charge 51 to enter second cartridge  
20 solute storage portion 35 before injection needle internal end 25 contacts puncturable cartridge end stopper 39 thereby allowing the mixing of solvent charge 51 and solvent charge 63. By varying the rate at which cartridge 31 is propelled toward end cap 3 after pushrod  
25 60 dislodges plug 61, and before internal injection needle tip 25 punctures puncturable end cap 39, the solvation time during which solvent charge 51 and solute 63 can be controlled.

Continued force toward puncturable cartridge sealing  
30 end cap 3 by piston 45 continues to propel needle 23 outward and into the target tissue until needle housing 18 is stopped by sealable end cap 3, thus positioning needle assembly housing 18 within needle assembly receiving chamber 11 which is of a larger diameter than  
35 cartridge residence chamber 15. The positioning of needle assembly housing 18 within needle assembly housing receiving chamber 11 allows flanges 19 and walls 17 of

needle assembly 18 to expand to irreversibly and securely receive and capture third cartridge injection needle portion 37 of cartridge 31. Continued pressure in the same direction causes piston 45 to move toward puncturable cartridge end stopper 39 thus causing  
5 expulsion of the mixed solvent charge 51/solute 63 solution through hollow injection needle 23 into the target tissue.

After injection of the mixed solvent charge 51/solute  
10 63 solution through hollow injection needle 23 into the target tissue, the direction of force on piston shaft head 49 is reversed, thus causing the withdrawal of irreversibly captured needle assembly housing 18 into cartridge housing 31 and the withdrawal of injection  
15 needle 23 from the target tissue so that injection needle external end 27 resides completely within cartridge housing 31.

Piston 45, although slidably seated in the bore of cartridge 31, is of a slightly oversize diameter so that  
20 the frictional force required to withdraw piston 45 back through the bore of cartridge 31 is much greater than the force required to withdraw cartridge 31 which has been captured by needle assembly housing 17 and needle  
assembly housing 17 having needle 23 attached  
25 therethrough from an injection site to reside wholly within cartridge housing 1.

Figure 2 shows an embodiment of the invention which differs from that shown in Figure 1 by providing a burstable membrane as a barrier between the solvent and  
30 solute portions of the cartridge and by presenting the solute in an elutable bead column. With reference to Figure 2, cylindrical cartridge 31 of rigid material such as water glass is slidably positioned within cartridge housing 1 and is provide with a three-portion chamber in  
35 which is stored solvent charge 251 and solute charge 263. Cartridge solvent portion 33 is separated from cartridge solute storage portion 35 by a membrane seat 271, a



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resilient circular U channel made from vulcanized rubber, which is rigidly attached and sealed to the internal walls of cartridge 31 either by pressure generated by oversizing the diameter of the wall adjacent to the cartridge wall or an industrial adhesive known to the art, into which is fitted a burstable membrane 273 of a material such as natural rubber or styrene film locked in by an O-ring [not shown].

Second solute storage portion 35 has stored therein a bead column 272 of ion exchange resins such as Rhom and Haas's Amberlite cationic or anionic resins. In this embodiment of the invention, the resins are saturated with the appropriate solute charge 263 and subsequently eluted by solvent charge 251. It should be noted that in most instances the critical factor in drug delivery is the dosage amount of solute charge 263 while a surplus of solvent charge 251 is widely tolerated. Supporting the base of the bead column 272 is a puncturable permeable grid 275. Bead column 272 is charged into cartridge solute storage portion 35 so that in operation of the invention solvent charge 251 moves through bead column 272, dissolving solute charge 263 before being expelled through hollow injection needle 23.

The relative lengths of needle assembly housing walls 17 needle assembly receiving chamber 11 and pushrod 260 are such that in operation of the device as described hereinbelow sharpened pushrod puncturing end 268 penetrates puncturable cartridge end stopper 39 and burstable membrane 273 before needle internal end 25 contacts puncturable end stopper 239. This can be best seen in Figure 2(a). By controlling the length of time between which burstable membrane 273 is punctured by pushrod 260 and needle tip 25 punctures cartridge end stopper 39 the solvation time in which solvent 251 moves through solute 263 can be varied as needed for particular solute/solvent combinations.

The embodiment of the invention shown in Figures 2(a)-2(c) operates in a similar manner to that described with reference to Figure 1 above and is further illustrated in Figure 2(a)-2(e) showing the device in four positions of the injection/retraction cycle. Figure 2(a) shows the invention in its initial storage position.

Figure 2(b) shows the invention after force has been applied to piston 45 through shaft head 49 of shaft 47, forcing cartridge 31 and needle assembly housing 17 having injection needle 23 rigidly disposed therethrough toward puncturable cartridge housing sealing end cap 3 sufficiently far so that pushrod 260 anchored in pushrod base 266 has punctured cartridge end stopper 39, grid 275, and burstable membrane 273 and has expanded the flanges of needle assembly housing 17 which, in this position, is shown bottomed out in needle assembly housing residence chamber 11 but has not yet been propelled sufficiently far that the internal end of needle 23 has punctured puncturable cartridge end cap 39. Figure 2(b) thus shows the device in a position wherein solvent 251 is exposed to solute 263 but does not yet have an avenue through injection needle 23 for expulsion from cartridge 31.

Figure 2(c) shows the device after cartridge 31 has been further propelled toward sealing end cap 3 a sufficient distance so that the flanges of needle assembly housing 17 have irreversibly captured the cap and neck portion of cartridge 31 and piston 45 has propelled part of the solvent charge 251 through solute 263 and into the third portion of the chamber of cartridge 31 for injection.

Although not shown, it is obvious that continued force on piston 45 propels an additional amount of solvent 251 through solute 263 to inject the required amount of the medicament whereupon barbs 204 irreversibly engage membrane seat 271 so that reversal of the force on piston 45 withdraws cartridge 31 needle assembly housing

17 and injection needle 23 to fully reside within cartridge housing 1 after the injection has occurred. Figure 2(d) shows the fully withdrawn cartridge with attached needle assembly housing and needle. Rigidly anchored into rubber plunger 45 are stainless steel barbs 204.

Figure 3 shows an embodiment of the cartridge of the present invention having liquid constituents in both upper and lower portions of the cartridge. This embodiment is known as a wet/wet cartridge. The temporary barrier device for separating the portions of the cartridge is a rotatable disk assembly valve separation barrier and trigger therefor that extends the time available for mixing. Figures 3(a), 3(b), 3(c) and 3(d) show three operating positions of the device.

With reference to Figure 3, cylindrical cartridge housing 1 is fitted with a shelf 374 that is integral with cylindrical cartridge housing 1 into which is imbedded a rigid rectangular spiral pushrod 382 coaxially aligned with cylindrical cartridge 31. An injection needle 323 is sufficiently offset in needle assembly housing 318 so as not to interfere with the operation of rectangular spiral pushrod 382. Cylindrical cartridge 31 is slidably positioned within cartridge housing 1 and is provided with two chambers in which are stored a solvent charge 351 and a solution charge 363. Solvent charge 351, such as Prostaglandin E, available from Upjohn Pharmaceutical, a vasodilator that is provided in a solution of absolute alcohol and must be diluted with sterile water before injecting, is stored in first portion 333 of cartridge 31 and solution charge 363, such as the diluent distilled water, is stored in second cartridge portion 335. First cartridge solvent portion 333 is separated from second cartridge solute storage portion 335 by a disk assembly valve comprising double disk valve seat 371, a circular stator disk 377, and a circular rotor disk 378. Double disk valve seat 371, a

resilient circular U channel made from castable silicone rubber, is rigidly attached to the internal walls of cartridge 331 either by pressure generated by oversizing the diameter of the wall adjacent to the cartridge wall or an industrial adhesive known in the art, into which is permanently fitted circular stator disk 377, made from rigid rubber with alternate quarters open and circular rotor disk 378, made from stainless steel with alternate quarters open, which is free to rotate in double disk valve seat 371. The disks are arranged so that the open quarters do not overlap thus leaving the disk assembly valve closed. This arrangement can be seen in Figure 3(a). Rigidly attached to circular rotor disk 378 by rods 379 is a driven slotted member 381. Driven slotted member 381 has a rectangular slot 380 of an appropriate dimension so that a rectangular spiral pushrod 382 will cause driven spiral disk 381 to rotate as it follows the spiral of spiral rod 382. The sharpened spiral tip 388 of rectangular spiral pushrod 382 is of a thickness, length and rotation to cause driven spiral member 381 to rotate 90 degrees and pierce cartridge end seal 339 without causing leakage therefrom.

The above described embodiment of the wet/wet cartridge syringe operates as described below.

Piston 45 is propelled towards end cap 3 by the application of force to plunger shaft head 49 in the direction of end cap 3 which force is communicated through plunger shaft 47 to piston 45 thus applying hydraulic pressure through solvent charge 351 disk assembly valve rotor 378 and stator 377 thus forcing cartridge 31 and needle assembly housing 318 having injection needle 323 fixedly attached therethrough towards end cap 3 simultaneously forcing cartridge 31 onto sharpened tip 388 of rectangular spiral pushrod 382 which slides freely through needle assembly housing aperture 320 thus also propelling injection needle 327 to puncture end cap 3 and thin wall 375. When the tip 388

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of rectangular spiral pushrod 382 passes through rectangular slot 380 so that driven spiral disk 381 turns as it follows the spiral curve of spiral tip 388. Rigid rods 379 cause circular disk assembly valve rotor 378 to rotate 90 degrees, thus opening the disk assembly valve. This is illustrated in Figure 3(b) and 3(c). It is clearly seen that the disk assembly valve opens as soon as spiral tip enters into slot 380 at the beginning of the injection cycle, allowing solution charge 363 and solvent charge 351 time to mix before internal injection needle tip 25 punctures puncturable cartridge end stopper 39. End stopper 39 is punctured near the end of the injection cycle. See Figure 3(c). The remainder of rectangular spiral pushrod 382 is linear so that no further rotation of valve rotor 378 occurs fixing the valve in an open position.

Figure 4(a) shows a detailed view of one embodiment of the invention providing a stopcock as a temporary barrier between chambers of the cartridge. The stopcock is provided with an operating cam which is actuated by a pushrod disposed between the external surface of the cartridge and the internal surface of the cartridge housing. This embodiment is also provided with independently actuated means for automatically agitating the mixing solvent and solute charges during the injection cycle of the invention.

With reference to Figure 4(a), cylindrical cartridge housing 1 is provided with a base shelf 474 that is integral with cylindrical cartridge housing 1 into which is imbedded a rigid rectangular spiral pushrod 482 formed from flat stainless steel and is disposed coaxially to cylindrical cartridge 1. Spiral pushrod 482 is provided with a sharpened spiral pushrod end 490. An injection needle 423 is offset in a needle assembly housing 418 to operate without interference from rectangular spiral pushrod 482. Needle assembly housing 19 is slidable in cartridge housing 1 and is provided with injection needle

423 fixedly attached therethrough and having needle internal end 425.

As in the embodiments shown in Figures 1, 2, 3, 4, and 7, cartridge housing 1 is provided with needle assembly housing residence chamber 11 of appropriate dimension to permit the expansion of needle assembly housing flanges 19 when needle assembly housing 418 resides wholly within chamber 11. Cylindrical cartridge 31 is slidably positioned within cartridge housing 1.

A first cartridge solvent reservoir portion 433 is separated from cartridge solute portion 435 by a stopcock assembly valve 420. Stopcock assembly valve 420 is made of materials known in the medical arts and can be of many different configurations such as those wherein the aperture of the valve is of an appropriate diameter to permit the cartridge piston to pass sealably therethrough. Additional embodiments of the stopcock assembly valve of the present invention are more fully elucidated in the description of Figure 5 below.

With respect to Figure 4(a), a valve operating pushrod 460 is shown fixedly attached to base shelf 474 and is freely disposed through an aperture (not shown) in needle assembly housing 418 for opening stopcock 420 and is outside cartridge 431 leaving rectangular spiral pushrod 482 free to cause tube 491 to continually rotate and is more fully shown in Figures 4(b) - 4(d). Fitted into the lower end of a tube 491 is driven spiral disk 481. Driven spiral disk 481 has an oval slot of a dimension so that the rectangular spiral pushrod 482 will cause driven spiral disk 481 to rotate as it follows the spiral pattern. Rigidly attached to tube 491 are agitating rotor blades 487 the lower one of which rests on a silicone ring 489 which acts as a bearing for the structure. A mesh annular frame 486 hangs over a tube top cap 495 that is closed and allows no solvent to enter tube 491. The spiral pattern on spiral pushrod 382 is of

a length to cause driven spiral disk 481 to rotate during the entire downward cycle of the syringe.

The above described embodiment of the two-component syringe of the invention operates as described hereinbelow.

Piston 45 is propelled towards end cap 3 by the application of force to plunger shaft head 49 in the direction of end cap 3, which force is communicated through plunger shaft 47 to piston 45 thus applying hydraulic pressure through solvent charge 51 stopcock assembly valve 420 and forcing cartridge 31 and needle assembly housing 417 having injection needle 460 fixedly attached therethrough towards end cap 3 and simultaneously forcing cartridge 31 onto rectangular spiral pushrod 482 which slides freely through needle assembly housing aperture 420 (not shown), thus also propelling injection needle 427 to puncture end cap 3 and thin wall 475. When the tip 488 of rectangular spiral pushrod 482 passes through oval slot 480, driven spiral disk 481 turns as it follows the spiral curve of shaft 490. Driven spiral disk 481 being rigidly attached to tube 491, will cause tube 491 to rotate continually, thus providing agitation to the mixing solvent and solute. This is most clearly seen in Figure 4(b) and 4(c).

Figure 5(a) - (e) illustrate an embodiment of the invention differing from the previously described embodiments by the provision of an elution maze for the solute and a stopcock disposed through the cartridge component of the invention and which is actuated by a set of ridges and grooves disposed within the cartridge housing. In a variation thereof, the stopcock can be configured to allow sealable passage therethrough.

Figures 5(a), (b), (c), (d), (e) and (f) show a two-component cartridge syringe of the present invention utilizing a two-chambered medicament cartridge slidable within a cartridge housing having an injection needle fixedly attached to the cartridge housing and an

actuating ridge and groove integral with the cartridge housing for operating a stopcock and guiding and positioning the cartridge.

With reference to Figures 5(a), (b), (c), (d), (e) and (f), a two-component cartridge syringe comprises a double ended substantially cylindrical cartridge housing 501 having an injection end and a cartridge operating end constructed of a rigid material suitable for injection molding such as linear polypropylene or polystyrene, and having a cartridge residence chamber 515 formed therein for slidably housing a two-chambered cartridge 531 and also having guide channel 512 and a channel ridge 510 positioned therein for operating and guiding a valve operating cam 584 and for engaging and rotating a cam protrusion 599 and valve rotor 583. The injection end of cylindrical cartridge housing 501 wall 516 is significantly thinned in order to allow the injection tip and shaft of hollow injection needle 523 to puncture an end wall 516 thereof when cartridge 531 is driven toward puncturable end cap 503 that also functions as a shock absorber when cartridge 531 is driven toward it. End cap 503 is formulated, as is known in the art, of a resilient material that will not core out when a needle is embedded in it or when the needle moves therethrough at high speeds and will adsorb efficiently an energy shock as might be transmitted by an expanding spring. One material having such properties and known in the art is chlorobutyl rubber. Cylindrical cartridge 531, constructed of a rigid material such as Pyrex glass, is slidably positioned within cartridge housing 501 and has two chambers in which are provided a solvent charge 551 and a solute charge 563. Solvent charge 551 is stored in a first portion 533 of cartridge 531 and solute charge 551 is stored in an elution maze 571 constructed and disposed in a second cartridge portion 535 in such a manner that solvent charge 551 is forced therethrough when a stopcock assembly 520 is actuated.



First cartridge portion 533 is separated from second portion 535 by stopcock assembly 520 comprising a cylindrical rotor housing/seal 585 made of a resilient material such as cast silicone rubber and provided with an aperture 595 that provides for the passage therethrough of solvent charge 551 into cartridge second portion 535 after cylindrical rotor housing/seal 585 is rotated by the relative movement of cartridge housing 501 with respect to cartridge 531 and the interaction of cam 522 with guide channel 512 and channel ridge 510.

Cylindrical rotor housing/seal 585 and a valve rotor 583 are sealably fitted through valve rotor seats 524 disposed in the walls of cartridge 531. Rotor seats 524 and valve rotor 583 are preferably injection molded from a general purpose lubricating nylon polymer such as Zytel 101L.

Aperture 595 of cylindrical rotor housing/seal 585 causes the stopcock assembly to act as a valve. This can best be seen in Figure 5(a). To the front end of cylindrical rotor cylinder 583 is attached a concentric cam 584 with a protruding hemisphere 599 which will cause the cylindrical rotor cylinder 583 to rotate 90 degrees when the cartridge 531 slides down the circular cylindrical cartridge housing past the channel ridge 510 and channel 512. This 90 degree rotation aligns the rotor aperture 595 with the cylinder bore allowing passage of solvent charge 551 into cylinder second portion 535. Second cartridge solute storage portion 535 has stored therein solute charge 563 in finely divided form on column trays 592 individually injection molded and sealably stacked to the desired height so that solvent charge 551 travels through one tray to the next before being expelled through hollow injection needle 523. Injection needle 523 made from hollow stainless steel tubing has an external tip 527 which does not protrude through sealing end cap 503.

The above described embodiment of the wet/dry, wet/wet syringe operated as described herein below.

5       Piston 545 is propelled towards sealable end cap 503 by the application of force to plunger shaft head 549 in the direction of end cap 503, which force is communicated through plunger shaft 547 to piston 545, thus applying hydraulic pressure through solvent charge 551 and stopcock assembly valve 520 and forcing cartridge 531 together with permanently attached needle assembly 593  
10       towards end cap 503 causing cartridge 531 to slide down cartridge housing 501. As the hemispheric portion 599 of cam 584 which is perpendicular to channel ridge 510, slides down guide channel 512 its radius end 506 engages the 45 degree incline 508 at the top of channel ridge  
15       510, starting cam 584 to rotate. This action is best seen in Figure 5(a).

20       The cam 584 is attached to valve rotor 503 whose aperture 595 is in the horizontal (closed) attitude when the hemispheric portion 599 of cam 584 is in its horizontal (closed) attitude.

      As the cam 584 slides down guide channel 512 the cam 584 rotates 90 degrees causing slot 595 to assume a vertical (open) attitude (this action can best be seen in Figure 5(b) thus lining up with the cartridge bore.

25       Continued movement by piston 645 toward end cap 503 propels needle 523 through puncturable cartridge end cap 503 and puncturable thin wall 516 into target tissue. The force needed to inject the needle into target tissue is in the order of 6 oz., while the backpressure needed  
30       to force the solvent charge 551 through the tray column is in the order of pounds. Therefore the open stopcock assembly valve will continue to allow the force to be translated through the piston to the cartridge. Once the cartridge 531 is seated in the down position so that  
35       needle assembly housing 593 is contacting end cap 503, solvent charge 551 is forced through elution maze 571 thus eluting solute charge 563 therefrom and the mixed

medicament is expelled through hollow injection needle 523 into target tissue. After injection of the mixed solvent charge 551 and solute 563 through hollow injection needle 523 into target tissue, the direction of force on piston shaft head 49 is reversed, thus causing the withdrawal of the cartridge 531 and injection needle 523 to reside completely within cartridge housing 501.

Figure 6 shows an embodiment of the present invention differing from the other described embodiments in that the separation barrier and the separation barrier attachment groove is recessed past the line of descent of the piston to allow passage thereof through the breached separation barrier and wherein the barrier breaching device is activated by an electromagnet or electronically actuated pin embedded in the wall of the substantially circular cartridge housing.

With reference to Figure 6 two-component cartridge syringe comprises a double ended substantially cylindrical cartridge housing 601 having a conically tapered injection end constructed of a rigid material suitable for injection molding such as linear polypropylene or polystyrene. A housing is provided with cartridge residence chamber 615 and a cavity 613 for an electromagnet 618. The lower end of cartridge housing 601, tip 616, is significantly thinned and made of easily puncturable material in order to allow a needle 618 to puncture a tip 616 when a cartridge 631 descends. Cartridge housing 601 is provided with a puncturable end cap 603 that also functions as a shock absorber when the cartridge 631 bottoms out.

Cylindrical cartridge 631, of rigid material such as Boron glass, is slidably positioned within cartridge housing 601 and is provided with a two-portion chamber in which is provided a solvent charge 651 and a solute charge 663. Solvent charge 651 is stored in a first portion 633 of cartridge 631, while solute charge 633 is stored in a second portion 635. A rectangular glass wall

protrusion 634 is provided in cartridge 631 to allow a membrane seat 671 to be recessed out of the line of descent of a piston 645. First portion 633 is separated from second portion 635 by membrane seat 671, a resilient circular U channel cast from silicone rubber which is rigidly attached to attachment on groove 632 of glass wall protrusion 634, either by pressure generated by oversizing the diameter of the membrane seat wall 636 adjacent to the attachment groove 632 or an industrial adhesive known in the art into which is fitted a puncturable membrane 673 such as a hydrophobic coated polystyrene film of .005" which film has the property of being shattered when pricked. The film is locked in by an O ring (not shown). A permanent magnet N 637 is held in place on the glass wall of cartridge 631 by silicone grease and which has the property, in a thin layer, .005-1.000" of acting as temporary adhesive. Rigidly attached to permanent magnet N 637 is a pin 638. A permeable tray 640 holds solute charge 663. N and S as used in magnets are conventions for opposite magnetic charges.

The above described embodiment of the mixing syringe operates as described herein below.

Cartridge 631 is propelled toward sealing end cap 603 by the application of force to plunger shaft head 649 in the direction of end cap 603 which force is communicated through the plunger shaft to piston 645 thus applying hydraulic pressure through solvent charge 651 and membrane seat 671 forcing cartridge 631 and permanently attached needle assembly 693 toward end cap 603 causing cartridge 631 to slide down cartridge housing 601. As cartridge 631 moves toward end cap 603, glass wall protrusion 634 trips contact switch 655 which closes the circuit (not shown) of battery 642 causing current to flow through magnetic windings 643 causing electromagnet 618 to be magnetic charged N and holding firmly in place relative to cartridge housing 601 permanent magnet S 637 and attached pin 638. As cartridge 631 continues in

motion toward end cap 603 as seen in Figure 6(b), pin 638 causes burstable membrane 673 to burst allowing solute charge 651 to enter into second portion 635 of cartridge 631. Piston 645 continues to propel cartridge 631  
5 towards sealable end cap 603 propelling needle 618 into target tissue. When cartridge 631 is seated onto end cap 603 the force toward end cap 603 on piston 645 will cause the piston to move toward end cap 603 as shown in Figure 6 position III forcing permanent magnet S to be move down  
10 the inner glass wall of cartridge 631.

The silicone grease that held permanent magnet S 637 onto the glass walls of cartridge 631 acts as a lubricant for piston 645 and also as an adhesive for magnet with a force of about 3 oz. Piston 645 can pass the recessed  
15 membrane seat 671 and expel the solvated solute charge through hollow needle 618 into target tissue.

The embodiment of the invention shown in Figure 7 illustrates a variation of that shown in Figure 1 but having a modified injection needle which also functions  
20 as a pushrod to burst a burstable barrier separating the two cartridge portions.

With reference to Figure 7 cylindrical cartridge 31 of rigid material such as water glass is slidably positioned within cartridge housing 1 and is provided  
25 with a three-portion chamber in which is stored a solvent charge 751 and a solute charge 763. A cartridge solvent portion having solvent 751 therein is separated from the cartridge portion having solute 763 therein by a burstable membrane 761 as in the embodiment shown in  
30 Figure 2, burstable membrane 761 is seated in cartridge 31 by a membrane seat made from vulcanized rubber which is rigidly attached and sealed to the internal walls of cartridge 31 either by pressure generated by oversizing the diameter of the wall adjacent to the cartridge wall  
35 or an industrial adhesive known to the art.

The solute storage portion of cartridge 31 is provided with a bead column of ion exchange resins

similar to that shown in Figure 2 which are saturated with the appropriate solute charge to be eluted by solvent charge 751.

5 Needle assembly housing 17 is provided with a hollow pushrod/injection needle 723 rigidly attached therethrough. Hollow pushrod injection needle 723 is provided with a sharpened pushrod injection needle internal end 725 having no aperture. Hollow pushrod injection needle 723 is also provided with a pushrod  
10 injection needle aperture 773 positioned in relation to needle assembly housing 17 such that pushrod injection needle aperture 773 is not exposed to the mixed solvent 751/solute 763 mixture until puncturable cartridge end stopper 39 is seated against the bottom of needle  
15 assembly housing 17 during the injection stroke of the device.

The operation of the device shown in Figure 7 is similar to that shown in the other embodiments, cartridge 31 being impelled by pressure provided through piston  
20 shaft head 49 forcing cartridge 31 toward puncturable cartridge housing sealing end cap 3. Such pressure is sufficient to break breakable cartridge positioning tab 771 allowing cartridge 31 to proceed toward puncturable cartridge housing sealing end cap 3. Continued downward  
25 pressure on piston head shaft 49 causes pushrod injection needle internal end which has no aperture to puncture puncturable cartridge end stopper 39 bead column 772 and burstable membrane 761. As in the other embodiments disclosed, the breaching of the barrier between the  
30 solvent and solute of cartridge 31 permits the joining those two chambers and the mixing of the solute and solvent. The position of pushrod injection needle aperture 773 permits access of the mixed medicament only after third cartridge portion 37 is completely captured  
35 and needle assembly housing 17 and needle assembly housing 17 with third cartridge portion 37 is fully within needle assembly receiving chamber 11.

With reference to Figure 8, various views of the needle housing of the present invention are shown. Figure 8(a) shows a perspective view of the needle assembly housing showing needle assembly housing bottom 18 needle assembly housing flanges 19 and needle assembly housing flange lips 21. Injection needle aperture 822 which is configured for the rigid attachment therethrough of an injection needle is also shown.

Figure 8(b) is a plan view of the housing of the present invention showing housing bottom 18 housing flanges 19 and housing flange lips 21 as well as injection needle aperture 822.

Figure 8(c) shows a sectional view through section A-A of Figure 8(b) showing housing bottom 18 housing flanges 19 and housing flange lips 21. In addition, an injection needle aperture 822 is shown disposed through housing bottom 18.

Figure 8(d) is a detailed cross-sectional view of a portion of Figure 8(c) showing injection needle aperture 822 in needle assembly housing bottom 18.

As can be seen with reference to Figures 8(a), (b), (c), and (d), and with reference to Figures 2, 3, 4, and 7, needle assembly housing 17 having an injection needle rigidly affixed therethrough operates in relation to a necked medicament container. More specifically, when the necked end of a medicament container is pressed into contact with the curved abutments of flanges 19 of needle assembly housing 17, the flanges 19 expand to receive the end of the necked medicament container and contract to securely capture the container when flange lips 21 are exposed to the narrowing recess forming the neck of the necked medicament container. As shown in Figures 8(a), needle assembly housing bottom 18 has injection needle aperture 822 therethrough for receipt of an injection needle. Such a needle can be molded therein, threaded therethrough, or snap fit therethrough or affixed in any other manner known in the art.

Although a pass-through valve having a barrel-shaped rotor may be adaptable for certain uses, a ball valve having a substantially spherical rotor and seat therefor is another preferred embodiment of the temporary  
5 breachable barrier of the invention. The ball valve rotor is provided with a cylindrical aperture therethrough of appropriate dimension so that, when the valve rotor is rotated to align the rotor aperture with the bore of the cartridge cylinder, the cartridge piston  
10 can pass sealably therethrough. This can be accomplished by providing the valve rotor with a cylindrical bore substantially identical to the cartridge bore through which the piston moves. Alternatively, by providing a cartridge piston of elastically deformable material such  
15 as silicone plastic or rubber which can compress or expand to pass sealably through the valve rotor, the contents of the cartridge can be more completely expelled. The ball valve seat is preferably integral to the cartridge walls and recessed sealably therein  
20 sufficiently far to permit the cartridge piston to pass sealably therethrough.

Figures 9(a), (b), (c), and (d) illustrate an additional embodiment of the invention wherein the means for separating the two chambers of the cartridge is a  
25 ball valve operated in much the same manner as the stopcock shown in Embodiment No. 5. A key aspect of this embodiment of the invention is the passthrough feature of the valve which permits the cartridge piston to pass sealably therethrough, thus evacuating the cartridge more  
30 completely.

With references to Figures 9(a), (b), (c) and (d), a cartridge housing 909 has a cartridge 981 slidably disposed therein. A cartridge housing 909 also has a  
35 needle assembly housing 929 slidably disposed therein between a cartridge 981 and a puncturable cartridge housing sealing end cap 937. A cartridge 981 comprises a glass cylindrical top element 969 having a first



cartridge solvent reservoir portion 907 therein and also having a piston 905 slidably seated therein. A cartridge 981 is further provided with a ball valve cast housing 911 having a substantially spherical ball valve 913 seated therein. A ball valve 913 also has a cylindrical channel 915 of a diameter greater than the bore of a cartridge 981.

A cartridge 981 is further provided with a glass element 925 which is attached to the injection end of ball a valve cast housing 909. A glass element 925 comprises a cartridge neck 927 and a puncturable cartridge end stopper 928. A ball valve 913 is further provided with an operating cam 919 disposed to rotatably engage a guide ridge 923 having an inclined plane 921 and a guide channel 949 disposed therein for guiding and operating a cartridge 981 and a ball valve 913, respectively.

The operation of the embodiment of the present invention shown in Figures 9(a), (b), (c) and (d) is very similar to the operation of the embodiment of the invention shown in Figures 5(a), (b), (c), (d) and (e). More specifically, force transmitted through a piston shaft head 901, a piston shaft 903, a rubber piston 905 and a solvent charge 906 forces a cartridge 981 toward a puncturable cartridge housing sealing end cap 937. The movement of a cartridge 981 causes a rotatable cam element 943 to engage an inclined plane 921 of a guide ridge 923, thus causing a 90 degree rotation of a rotatable cam element 943 and of a ball valve 913 which is fixedly attached thereto, and causing the alignment of cylindrical aperture 915 with the bore of a first cartridge solvent reservoir portion 907 and with a bore of second cartridge solute portion 979 to such an extent that a rubber piston 905 can pass sealably through a ball valve 913 forcing a solvent charge 906 into a second cartridge solute portion 979 and through a solute grid 988 having a medically active substance disposed therein.

The medically active substance is eluted by solvent charge 906 as it passes through a solute grid 988 recessed into the neck portion of a cartridge 981 to permit a piston 905 to almost completely evacuate cartridge 981. Simultaneously with the downward movement of a cartridge 981 is the movement of a needle assembly housing 929 into a needle assembly housing expansion chamber 933 allowing the expansion of the needle assembly housing flanges 926 and the capture of a cartridge neck 927 by a needle assembly housing 929 and the puncturing of puncturable cartridge end stopper 928 by an injection needle internal end 931. Continued pressure on a rubber piston 905 causes the complete expulsion of a solvent charge 906 and the eluted solute contained therein.

Reversing the direction of force placed on a rubber piston 905 causes retraction of a cartridge 981 and an irreversibly captured needle housing assembly 929 so that a cartridge 981, a needle housing assembly 929, and an injection needle 985 reside wholly within a cartridge 981.

**Table 1**

EMBODIMENT NO.	TYPE OF BARRIER	BREACHING TRIGGER	SOLUTE VEHICLE	MIXING MECHANISM
1	Wedge plug	Pushrod	Tray	None
2	Burstable membrane	Pushrod (PIN)	Column of beads	Backpressure of column
3	Disk valve	90 degree spiral rod	Packing	Backpressure of packing
4	Stopcock	External Pushrod	Doughnut prepack	Rotating Paddles
5	Stopcock	Integral pushrod/cam	Elution Maze	Backpressure of Maze
6	Passthrough membrane	Electromagnetic pin	Tray column	Backpressure of column
7	Burstable membrane	Pushrod/Injection needle	Bead column	Backpressure of column
9	Passthrough stopcock	Integral pushrod/cam	Grid in Cartridge Neck	Backpressure of prepack

Table 1 lists some major characteristics of the eight embodiments of the cartridge shown in Figures 1-7 and 9. The listed combinations of elements are illustrative only and are intended to demonstrate some of the permutations of the invention. For example, although not shown in the drawings or table, it is obvious from the description herein that a passthrough stopcock can be substituted for the stopcock in Embodiment No. 5. Similarly, an elution maze can be substituted for the bead columns of Embodiment Nos. 7 or 2.

Thus, with reference to Figures 1-9, it can be clearly seen that by performing only the simple operation of applying downward pressure on the operating piston of any of the various embodiments of the present invention, that joining of the solvent and solute chambers, mixing of the two medicament components, and the injection of

the medically active substance is achieved. It can also be clearly seen that the simple operation of reversing the direction of force on the operating piston, that the injection needle is both withdrawn from the injection  
5 site and withdrawn to reside wholly within the cartridge housing of the invention.

Thus the present invention provides a series of embodiments wherein the relative motion of a prepackaged cartridge containing at least one medically active  
10 substance and a housing for the cartridge triggers the breaching of a barrier between a cartridge chamber having the medically active substance therein and another cartridge chamber containing a physiologically acceptable solvent or diluent.

Preferred methods of using the two-component syringes of the types described above are both with an adaptor for manual use and with an automatic injection/aspiration  
15 device of the type described herein. Another preferred method is to provide a plunger handle in place of the piston operating shaft of any of the described syringe embodiments. Thus, the syringes can be used manually  
20 without need for other actuating power.

With reference to the resilient materials disclosed herein, such materials are those standard in the medical  
25 and dental packaging and hypodermic syringe art such as rubber, plastics, and other synthetic and non-synthetic materials known in the art for use in fulfilling similar and related objectives. It is also clear that all of the embodiments of the invention disclosed herein are adapted  
30 to be manufactured by standard medical and dental container and device manufacturing equipment.

Also, the cartridges of the present invention are adapted to contain standard amounts of solvent and appropriate amounts of solute for standard dosages of the  
35 particular medically active substance to be administered.

"Cylindrical" means having a shape or cavity described by a line which always has a point in common

with a given closed curve, and which line moves so that it is always parallel with a given line not in the plane of the closed curve. Thus, a right circular cylinder is one having two equal parallel circular bases and a perpendicular axis, and a right elliptical cylinder is one having two equal parallel elliptical bases and a perpendicular axis. In the context of the invention, it can be seen that the relationship between the various cartridge embodiments and their corresponding cartridge housings is that of a piston fitted to a cylinder. That is, the cartridge housing bore (cylinder) acts as both container and guide for the cartridge (piston) as the device operates. With respect to the various pistons of the cartridges, each operates much the same as a standard syringe plunger known in the art.

By "substantially cylindrical" it is meant that the housing and corresponding cartridge and needle housing assembly of a particular embodiment of the invention are of appropriate relative configuration, though not precisely cylinders, that the relative movement of the various components approximates the action of a piston or pistons within a cylinder.

By "sealably" with regard to piston movement through a breachable temporary barrier means is meant sealed sufficiently while moving through the breachable barrier that fluid is driven therethrough by the piston.

The advantages and characteristics of the injection/aspiration device and cartridge vial for the storage and injection of single-component medicaments of the present invention can be elucidated from the following detailed description of a preferred embodiment of the injection/aspiration device and cartridge vial, to be taken as examples and not as limitations in conjunction with the accompanying drawings.

The injection/aspiration device, illustrated in Figure 10, comprises: a housing 1201 for disposition of the various components having a chamber 1219 for

reversibly receiving a cartridge vial of a type as described below and in Figures 11 and 12, a d.c. motor 1203, a lead screw 1205, a linear bearing 1207 for holding a lead nut, a lead nut 1213 surrounding the lead screw, and armed/safety injector switch 1209, indicating light emitting diodes 1211, a plunger 1215 attached to lead screw 1205, a cartridge vial 1217 disposed within chamber 1219, an electronic control unit 1221, an injector trigger button 1223, a d.c. power source 1225, an on/off switch 1227, a cartridge/ampule position locking solenoid 1229 having cartridge/ampule position locking solenoid shaft 1231, aspirated fluid sensor 1233, and plunger shaft rate/position/direction sensor 1235.

The injection/aspiration device of the invention operates in conjunction with cartridge vials as described hereinbelow. All of the components of the device are energized by d.c. power source 1225 through the operation of switch 1227. D.c. motor 1203 propels lead screw 1205 which is attached to lead nut 1213 and plunger shaft 1215 which is reversibly attached to cartridge vial shaft end 1216 by means of a mechanical keyway provided at the end of plunger shaft 1215. Linear bearing 1207 is provided for smooth operation of lead screw 1205 and plunger shaft 1215. Lead screw nut 1213 is provided as an attachment means for connecting lead screw 1205 to plunger shaft 1215. Electronic control unit 1221 is a programmable electronic processor connected by means of wires not shown to DC motor 1203 to control the rate, direction, and extent of movement of lead screw 1205, plunger shaft 1215 and, thereby, the rate, extent of movement, and direction of movement of cartridge vial shaft end 1216. Cartridge vial shaft end 1216 can be of any type configured to securely but reversibly attach to plunger shaft 1215.

Similarly, as described below, plunger shaft 1215 can be adapted to operate other types of cartridge vials such as those designed to be used with a spear type shaft of

a type known in the dental cartridge field. The electronic control unit 1221 is programmed by means of a programmable read-only memory (PROM), and a programmable array logic (PAL) which, depending on the application of the device, can be interchanged to adapt the device to the age or sex of the patient, the location parameters of the injection, (such as intramuscular, subcutaneous or intravenous) for the rate of needle withdrawal and insertion, and for the rate of medicinal charge injection. The electronic control unit also comprises electronic timers which control the overall timing and specific rates during the injection process. A set of programmed instructions are stored in a replaceable and interchangeable memory chip (not shown) in electronic control unit 1221. By either interchanging memory chips or by reprogramming programmable memory chips, the various functions of the injection/aspiration device can be controllably varied. Cartridge/ampule position locking mechanism 1229 is a solenoid which can be activated to lock a cartridge vial in a particular position by means of cartridge/ampule position locking solenoid shaft 1231 so that blood or other fluids can be aspirated. Although a solenoid and solenoid shaft are described herein as a locking mechanism, it can be clearly seen that many other means for accomplishing the objective of the device to lock any type of cartridge vial in a particular position in the injection/aspiration device housing can be used.

Similarly, although programmable and/or interchangeable memory chips are described examples herein, it can be clearly seen that many other means for programming the stated functions could be used to accomplish the objectives of the invention.

It is also clear that although a d.c. motor and power source and electronic components are described herein as means for controlling the various rates of operation of the various components of the invention that other means such as compressed gas and valves could also be used.

Although not shown in Figure 10, the various electronic and electrical components of the invention are connected electrical circuitry.

5 It should also be clear that many different means for securely connecting to and easily disengaging a cartridge vial to and from plunger shaft 1215 are possible. As an example and not described as a limitation, Figure 12 shows plunger shaft 1047 of an injection/aspiration device having pointed barbed plunger shaft head 1049  
10 similar to pointed shafts known in the dental injection cartridge field which is driven a sufficient distance into piston 1045 during operation of the invention that a sufficiently secure connection is made to operate piston 1045 in both directions. Disconnection of barbed  
15 head 1049 from piston 1045 is achieved by the retraction of plunger shaft 1047 and plunger shaft head 1049 a sufficient distance into lead nut 1213 which is of an appropriate internal diameter to accomplish the disconnection.

20 The cartridge vial portion of the invention includes a hollow injection/aspiration needle attached to one piston with its external pointed end initially disposed within a sealed end cap for sanitary purposes. A second piston is also provided in the cylindrical bore to  
25 operate in conjunction with the first piston to impel the injection needle and the injection fluid into the subject and then withdraw the injection needle and first piston from the subject through the sealed end cap sufficiently so that the point of the needle need not be exposed to  
30 the atmosphere before, during, or after operation of the invention. The present invention provides a means for withdrawing the needle tip into a disposable cartridge immediately after the injection and before the injector device is withdrawn from contact with the subject. This  
35 reduces the risk of unintentional exposure to a used needle tip by both users and non-users because the needle tip need never be exposed.



The programmable automatic injector portion of the invention includes a chamber for insertion of a vial, a piston operating plunger for operation of the vial, and a power source for operating the plunger. The injector  
5 also includes a controller invention can be used to aspirate blood or other fluids.

#### Cartridge Vial Embodiments:

The advantages and characteristics of the cartridge vial and injection/aspiration device according to the  
10 present invention can be elucidated from the following detailed description of one embodiment of the injection/aspiration device and three embodiments of the cartridge vial, to be taken as examples and not as limitations in conjunction with the accompanying  
15 drawings.

With reference to Figure 12, a cartridge vial comprises a double-ended circularly cylindrical housing 1001 constructed of rigid material and having a cartridge/ampule position locking solenoid shaft aperture  
20 1053, aspirated fluid sensor apertures 1042 an ampule residence chamber 1015 and cylindrical needle housing assembly receiving chamber 1011. Cartridge housing 1001 is provided with a puncturable sealing end cap 1003 of resilient material, a plastic needle guide 1005 rigidly  
25 embedded in the end cap 1003 and having needle guide aperture 1007 formed therein and an injection device positioning projection 1009. The needle assembly receiving chamber 1011 is further provided with curved abutments 1013 of appropriate configuration to allow the  
30 needle assembly housing 1016 to both enter and withdraw from needle assembly housing receiving chamber 1011. Needle assembly housing 1016 and ampule 1031 are both initially disposed within ampule residence chamber 1015. A glass ampule 1031, positioned within the cartridge, is  
35 provided with a three portion chamber in which is stored

a fluid charge 1051. The first portion 1033 of ampule 1031 freely communicates with second portion 1035 and third portion 1037. Third portion 1037 is provided with a puncturable ampule stopper 1039 of a resilient material. An ampule piston chamber abutment 1040 forms the transition between first ampule portion 1033 and second ampule portion 1035 and forms a stop for a piston 1045 during operation of the invention. The external portion of the transition between first ampule portion 1033 and second ampule portion 1035 forms an ampule shoulder 1041. Ampule 1031 is further provided with flange engaging lips 1043 which are formed by the narrowing transition area between second chamber portion 1035 and third chamber portion 1037.

Ampule 1031 is further provided with a piston 1045 of resilient material for reversibly engaging a pointed plunger shaft head 1049 having a plunger shaft 1047 of an injection/aspiration device. Such an ampule could be reversibly engaged to the injection/aspiration device by many other means, other than a piston like piston 1045 as shown, such as a T-shaft and keyway or any other means providing secure reversible engagement of a cartridge device to an injection/aspiration device.

Needle assembly housing 1016 is provided with a needle assembly housing bottom 1018, needle housing walls 1017, needle assembly housing flanges 1019 and needle assembly housing lips 1021 disposed for securely engaging ampule 1031. Needle assembly housing 1016 is further provided with a hollow injection needle 1023 which passes therethrough and has an internal tip 1025 disposed toward puncturable ampule stopper 1039 and an external tip 1027 which passes through aperture 1007 of needle guide 1005 but does not protrude through sealing end cap 1003.

Needle assembly housing walls 1017 are of sufficient length so that, in operation of the cartridge as described hereinbelow, third ampule portion 1037 is captured by the engagement of needle assembly housing

flange lips 1021 by flange engaging step 1043 of ampule 1031 before needle internal end 1025 contacts puncturable ampule end stopper 1039 and when ampule 1031 has been propelled a sufficient distance toward puncturable  
5 cartridge sealing end cap 1003 that needle assembly housing 1016 is fully within needle assembly housing receiving chamber 1011.

Although a bar code indicator is seen as an efficient means for labeling both the cartridge vial and  
10 injector/aspirator components of the invention, any other means or multiple means could be employed to label the invention for machine readable purposes and for human readable purposes. For instance, both components of the invention could be labeled concurrently with readable  
15 magnetic strips, braille bumps and alphanumeric symbols.

The above-described embodiment of the ampule type cartridge vial of the invention operates as described hereinbelow.

Piston 1045 is propelled toward sealable end cap 1003  
20 by the application of force to plunger shaft 1047 which force is communicated through plunger shaft head 1049 to piston 1045 thus applying hydraulic pressure through fluid charge 1051 and forcing ampule 1031 onto needle assembly 1016. Continued pressure on plunger shaft head  
25 1047 is communicated through needle housing flanges 1019 needle housing walls 1017 and needle housing bottom 1016 to needle 1023, thus propelling needle 1023 through needle guide aperture 1007 causing external needle tip 1027 to puncture puncturable end cap 1003. Continued  
30 force toward puncturable cartridge sealing end cap 1003 by piston 1045 continues to propel needle 1023 outward until needle housing 1016 is stopped by sealable end cap 1003, thus positioning needle assembly housing 1016 within needle assembly receiving chamber 1011 which is of  
35 a larger diameter than ampule residence chamber 1015. The positioning of needle assembly 1016 within the needle assembly receiving chamber allows flanges 1019 and walls

1017 of needle assembly 1016 to expand to irreversibly and securely receive and capture the third portion 1037 of ampule 1031. Continued pressure in the same direction causes puncturable ampule stopper 1039 on ampule 1031 to be driven into internal needle tip 1025 thus puncturing ampule stopper 1039 and causing ampule stopper 1039 to contact needle assembly housing bottom 1018. At this time in the operation of the invention, cartridge/ampule position locking solenoid 1029 (shown in Figure 10 but not shown in Figure 12) is energized causing cartridge/ampule position locking solenoid shaft 1031 (also shown in Figure 11 but not shown in Figure 12) to extend through cartridge/ampule position locking solenoid aperture 1053 thus locking ampule 1031 and needle assembly 1017 tightly against needle guide 1005.

The direction of force on plunger shaft head 1049 may then be reversed causing a slight withdrawal of piston 1045 away from end cap 1003, thus causing aspiration into fluid 1051 in ampule 1031 of physiological fluid(s) if needle tip 1027, now located at a possible injection site in tissue, is in communication with such fluid. An aspirated fluid sensor 1233 and light source, such as a photodiode or photocell 1232 in the injection/aspiration component of the invention (shown in Figure 10 but not in Figure 12), then scan the fluid in ampule 1031 through aspirated fluid sensor apertures 1042 to spectrophotometrically detect the presence of physiological fluid(s).

If no fluids are detected and it is regarded as desirable or appropriate that none be aspiratable from an injection site for the drug being administered, or if fluid(s) that are detected do not indicate that the possible injection site, at which needle tip 1027 is located is undesirable or inappropriate, the injection cycle continues and the site at which needle tip 1027 is located, is employed as the injection site. Continued force in the same direction toward end cap 1003 on piston

1045 causes the expulsion of fluid charge 1051 through needle 1023 into the subject. In operation of the invention, with respect to an automatic injection/aspiration device of the type discussed above, the rate of propulsion of piston shaft head 1049 is varied to control the rate of insertion of needle 1023 and the rate of injection of fluid charge 1051. Also in the operation of the invention, a typical time for this sequence of inserting hollow injection needle 1023 is on the order of 100 milliseconds. After the injection of fluid charge 1051 the operational sequence is continued into the retraction/needle capture stage by the reversal of force on piston shaft head 1049 thus causing pressure on piston 1045 to be directed away from sealing cap 1003. The partial vacuum created by the withdrawal of piston 1045 causes ampule 1031 to retract from needle 1023 a sufficient distance so that internal needle tip 1025 no longer penetrates puncturable ampule end stopper 1039. The retraction of ampule 1031 from needle tip 1025 is assisted by the biasing force caused by the contact between curved needle assembly housing flanges 1019 and curved ampule shoulders 1041. Thus, needle assembly housing flanges 1021 are then engaged to flange engaging steps 1043 on ampule 1031. Locking solenoid shaft 1231 (shown in Figure 10 but not in Figure 12) is then withdrawn allowing further retention of the connected ampule/needle assembly. The ampule and needle assembly, thus irreversibly engaged, is withdrawn as piston 1045 is withdrawn by continued force in the direction away from puncturable sealing end cap 1003 thus withdrawing needle 1023 from the injection site a sufficient distance so that external needle tip 1027 is captured completely within needle assembly receiving chamber 1011. Thus, no part of needle 1023 need ever be exposed to any environment other than the subject's tissues or the inside of the cartridge vial. A typical time for

operation of the withdrawal/needle capture sequence is on the order of 200 milliseconds.

During operation of the invention, if an undesirable or inappropriate physiological fluid (e.g. blood) or lack of physiological fluid (e.g., lack of blood if an intravenous injection is intended) is detected by aspirated fluid sensor 1033, the injection sequence may be automatically stopped, thus preventing the injection of medicine or other fluids into an undesirable or inappropriate injection site.

With reference to Figure 13, an embodiment of the cartridge vial of the present invention intended for injections where no aspiration is necessary is illustrated. Cartridge 1401 is provided with slidable ampule 1431 having piston 1445 for the receipt of a barbed plunger shaft head known in the dental injection cartridge field and having a second ampule portion 1435 which is smaller than third ampule portion 1437 the transition area therebetween forming an engaging surface for engaging flanges 1419 of needle housing assembly 1418. Needle assembly housing 1418 is provided with needle assembly housing walls 1417 of sufficient length that when the flanges capture third portion 1437 of ampule 1431 needle tip 1425 has already punctured puncturable ampule end stopper 1439. It can thus clearly be seen that the retraction of needle assembly housing 1418 and needle 1423 are accomplished without permitting the withdrawal of needle tip 1425 from puncturable end cap 1439.

The additional advantages and characteristics of a non-ampule type embodiment according to the present invention can also be elucidated from the following detailed description of a second embodiment of the cartridge vial component, to be taken as an example and not as a limitation in conjunction with the accompanying drawings.

The cartridge type vial illustrated in Figure 11 comprises: a double-ended circularly cylindrical glass tube 1101 provided with a puncturable sealing end cap 1103 of resilient material, a rigid plastic needle guide 1105 rigidly embedded in the puncturable end cap, and a first piston 1117 slidably seated within the bore 1118 of the cartridge. First piston 1117 is provided with an operating rod engagement shaft 1119 having shaft end 1120. The cartridge also comprises a second piston 1115 which is also slidably disposed within the bore 1118 of the cartridge. An internal end 1111 of hollow injection needle 1107 passing through piston 1115 and is rigidly attached thereto by a needle anchoring washer 1113. Hollow injection needle 1107 also has an external end 1109 which extends through a cylindrical aperture 1104 in needle guide 1105 so that tip 1109 at the external end does not pass through puncturable end cap 1103. Cylindrical aperture 1104 is of sufficient diameter to allow the expulsion of air from chamber 1125 during operation of the device. Second piston 1115 is also rigidly fitted with a stainless steel engaging barb 1121 which extends toward first piston 1117. Medicinal fluid charge 1123 is disposed between piston 1117 and piston 1115.

The cartridge vial of the invention operates as described hereinbelow.

The space in bore 1118 between piston 1117 and piston 1115 is filled with a charge of fluid medicine 1123 to be injected into a subject. Piston 1117 is propelled by means of a rigidly connected piston rod 1119 toward piston 1115 forcing piston 1117 toward piston 1115 thus applying hydraulic pressure through fluid charge 1123 to piston 1115 which forces piston 1115 longitudinally through the bore 1118 of the cartridge. This in turn drives hollow injection needle 1107 which is guided by needle guide 1104 through puncturable end cap 1103. Continued pressure on piston shaft head 1120

communicated through piston shaft 1119 drives piston 1115 onto needle guide 1104 which stops piston 1115. Cartridge/ampule position locking solenoid 1229 (not shown in Figure 11, see Figure 10) is then operated to  
5 insert solenoid shaft 1231 (not shown in Figure 11, see Figure 10) thus locking cylinder 1101 against end cap 1103.

The direction of force on piston plunger shaft head 1120 may then be reversed to cause a slight withdrawal of  
10 piston 1117 away from end cap 1103 thus causing aspiration of physiological fluid(s), into fluid charge 1123, if needle tip 1109, now located at a possible injection site in tissue, is in communication with such fluid. Aspirated fluid sensor 1233 and light source  
15 (photodiode or photocell 1232) (shown in Figure 10 but not in Figure 11) in the injection/aspiration component of the invention (shown in Figure 11 but not in Figure 10) then scans the fluid in the bore between piston 1117 and piston 1118 to detect the presence of physiological  
20 fluid(s). If no fluids are detected and it is regarded as desirable or appropriate that none be aspiratable at the possible injection site at which needle tip 1109 is located, or if the fluid(s) that are detected do not indicate that the possible injection site is undesirable  
25 or inappropriate, the injection cycle continues with the possible site used as the actual injection site or injection of the medicinal charge.

Continued force on piston 1117 through piston shaft 1119 then causes expulsion of the medicinal fluid charge  
30 1123 through hollow injection needle 1107 and into the subject. Continued force on piston shaft 1119 impels piston 1117 to be within a predetermined distance from piston 1115 sufficiently onto barb 1121 to irreversibly lock needle 1107 and piston 1117 to piston 1115 as a last  
35 portion of medicinal fluid charge 1123 is expelled from the bore. Locking solenoid shaft 1231 (not shown in Figure 11, see Figure 10) is then withdrawn allowing



withdrawal of the cartridge. When the direction of the force on piston shaft 1119 is reversed, piston 1117 withdraws away from end cap 1103 through the cartridge bore drawing piston 1115 which has been locked to piston 1117 by means of stainless steel locking barb 1121 away from needle guide 1104 thus withdrawing needle 1107 which is rigidly attached by anchor washer 1113 to piston 1115. Continued force in this withdrawal direction on piston 1119 withdraws point 1109 of needle 1107 through puncturable end cap 1103 and needle guide 1104 so that needle end 1109 is captured within the cylindrical bore of the cartridge, thus the entirety of needle 1107 is disposed completely within bore 1118 of the cartridge after the injection cycle is completed.

During operation of this embodiment, if an undesirable or inappropriate physiological fluid (e.g. blood) or lack of physiological fluid (e.g., lack of blood if an intravenous injection is intended) is detected by aspirated fluid sensor 1233 the injection sequence is automatically stopped, thus preventing the injection of medicine or other fluids into an undesirable or inappropriate injection site.

Although a preferred method of using the cartridge vials or mixing syringes of the types described above is with a powered automatic injection/aspiration device also as described above, it can be clearly seen that a manually or mechanically powered injection device, such as one powered with spring tension, could be configured to operate such cartridge vials. It is also clear that any of the cartridge vials or mixing syringes described herein can be adapted for manual use without need for additional apparatus to actuate the syringe or vial.

For example, by providing an actuator rod functionally similar to that of a conventional syringe plunger in place of operating rod engagement shaft 1120, shown in Figure 11, a cartridge or syringe to insert the injection needle into a subject, inject the medicament,

and withdraw the needle, is easily achieved. It is also clear that, in those embodiments adapted for retrieving the injection needle to reside wholly within the cartridge or syringe walls, can also be easily achieved.

5       With reference to the resilient materials disclosed herein, such materials are those standard in the medical and dental packaging and hypodermic syringe art such as rubber, plastics, and other synthetic and non-synthetic materials known in the art for accomplishing similar and  
10       related objectives. Also, all of the embodiments of the cartridge vials disclosed herein are adapted to be manufactured by standard medical and dental ampule and container manufacturing equipment.

15       Similarly, the cartridge vials disclosed herein are adapted to contain, when fully charged, from 0.1 to 100 milliliters of fluid. However, more typically such vials will contain, when fully charged, from 0.5 to 10 milliliters of fluid.

20       The needles will have lengths and gauges, and will be made of materials, that are standard in the hypodermic syringe/needle art.

What Is Claimed Is:

1. A cartridge vial for fluid injection, comprising:

(A) a cartridge having a first end and a second end, said cartridge having a cylindrical bore defined by a wall extending between said first end and said second end, said bore being suitable for storing a fluid charge to be expelled therefrom;

(B) a first piston and a second piston positioned within said bore and being slidably seated against said cylindrical wall of said bore, said first piston comprising means for reversibly engaging a plunger,

(C) a puncturable end cap which is immovably attached to said second end of said cartridge and which comprises a needle guide,

(D) a hollow injection needle having an external tip and an internal tip, said internal tip being rigidly attached to and passing through said second piston, and said external tip extending toward said end cap without protruding therefrom,

(E) means for locking said first piston and said second piston irreversibly together when said first piston and said second piston are a predetermined distance apart.

2. A cartridge vial according to claim 1 further comprising a puncturable end cap attached to said second end of said cartridge, said puncturable end cap being self-sealing.

3. A cartridge vial according to claim 1 further comprising a readable indicator.

4. A cartridge vial as in claim 1 wherein said means for irreversibly locking said first and second pistons

together comprises barbs attached to at least one of the slidably disposed pistons.

5. A device as in claim 1 wherein said means for irreversibly locking said first and second pistons together comprises hook and loop connectors disposed respectively on the two said pistons.

6. A programmable automatic injection/aspiration device comprising:

(A) a housing,

(B) a chamber disposed within said housing for reversibly receiving a cartridge vial,

(C) a piston operating plunger slidably disposed within said housing,

(D) means, disposed within said housing, for propelling said plunger,

(E) programmable controller means for adjustably controlling the rate of movement of said plunger via said propelling means.

7. A device as in claim 6 wherein said controller means includes means for controlling the direction of said plunger.

8. A device as in claim 6 wherein said controller means includes means for controlling the extent of movement of said plunger.

9. A device as in claim 6 further comprising a programmable processor for directing said controller

10. A device as in claim 6 further comprising sensor means for detecting the rate of movement of said plunger.

11. A device as in claim 6 further comprising sensor means for sensing the direction of movement of said plunger.

12. A device as in claim 6 further comprising sensor means for sensing the extent of movement of said plunger.

13. A device as in claim 6 further comprising indicator means for indicating the rate, direction, and extent of movement of said plunger and for indicating the amount of fluid remaining and expelled from a fluid vial.

14. A device as in claim 6 further comprising locking means for preventing unintentional discharge of said device.

15. A device as in claim 6 further comprising means for locking said cartridge vial in a particular position in relation to said injection/aspiration device housing chamber so that said first piston can operate to aspirate fluids into said vial.

16. A device as in Claim 6 further comprising a readable indicator for matching cartridge vials and ampules to said device and for indicating patient information.

17. A device as in claim 6 further comprising aspirated fluid sensor means for detecting aspirated fluids.

18. A device as in claim 17 wherein said sensor means is a photoelectric cell.

19. A method of administering fluid medication, comprising :

(A) Providing a cartridge vial for fluid injection, said cartridge vial comprising:

(i) a cartridge having a first end and a second end, said cartridge having a cylindrical bore defined by a wall extending between said first end and said second end, said bore being suitable for storing a fluid charge to be expelled therefrom;

(ii) a first piston and a second piston positioned within said bore and being slidably seated against said cylindrical wall of said bore, said first piston comprising means for reversibly engaging a plunger,

(iii) a puncturable end cap which is attached to said second end of said cartridge and which comprises a needle guide,

(iv) a hollow injection needle having an external tip and an internal tip, said internal tip being rigidly attached to and passing through said second piston, and said external tip extending toward said end cap without protruding therefrom,

(v) means for locking said first piston and said second piston irreversibly together when said first piston and said second piston are a predetermined distance apart, and

(vi) means for locking said vial in a particular position in relation to said programmable automatic injection/aspiration device so that said first piston can be operated to aspirate fluid,

(B) propelling said plunger shaft to insert said needle into a subject; then

(C) locking said vial in a particular position in relation to said injection/aspiration device so that said vial can be operated to aspirate; then

(D) propelling said plunger shaft in a reverse direction to interrogate by aspiration an injection site; then

(E) automatically scanning said vial to insure the absence of blood or other physiological fluids; then

- (F) propelling said plunger shaft to inject fluid through said needle; then
- (G) withdrawing said needle from said injection site; then
- (H) retracting said needle a sufficient distance so that said needle thereafter resides completely within said cartridge, and
- (I) controlling said propelling of said plunger shaft as to rate, direction, and extent of movement.

20. A method as in claim 19 further comprising the step of retracting said needle a sufficient distance so that said needle thereafter resides completely within said cartridge after said step (E) when blood or other physiological fluid is detected by said aspirated fluid sensor.

21. A cartridge vial for fluid injection comprising:

(A) a cartridge, having a first end and a second end, said cartridge having

a cylindrical bore which is widened at said second end of said cartridge to form a cylindrical needle housing assembly residence chamber for reversibly receiving a needle housing assembly, and

a puncturable end cap, said end cap sealing said second end of said cartridge and having a needle guide disposed therein;

(B) an ampule disposed within said cartridge bore having a first cylindrical portion, a second cylindrical portion adjacent to and narrower than said first portion, and a third cylindrical portion adjacent to said second portion and being adjacent to and wider than said second portion, said ampule being suitable for storing a fluid charge to be expelled therefrom;

(C) a piston within said first portion of said ampule and being slidably seated in said ampule, said

piston comprising means for reversibly engaging a plunger;

(D) a puncturable ampule end stopper rigidly attached to and sealing said third portion of said ampule; and

(E) a needle housing assembly disposed in said cylindrical bore of said cartridge said needle housing assembly comprising

a housing,

a hollow injection needle rigidly attached to said housing and having an internal end and an external end, said internal end of said needle extending through said needle assembly housing toward said puncturable ampule end stopper, and said external end of said hollow injection needle extending toward said puncturable end cap of said cartridge without protruding therefrom,

said housing having locking means for irreversibly locking said needle assembly housing to said ampule when said needle cap assembly and said ampule are a predetermined distance apart.

22. A cartridge vial according to Claim 21 further comprising a readable indicator.

23. A cartridge vial according to claim 21 wherein said cartridge vial is provided with an aperture for engaging said injection/aspiration device housing chamber vial position locking means.

24. A mixing syringe for two-component medicaments comprising:

(A) a cartridge housing having a first end and a second end, said cartridge housing having a substantially cylindrical cartridge housing bore; (B) a slidable cartridge disposed in said cartridge housing bore and having a first end, a second end, and a temporary sealing barrier disposed between said first and



second ends and separating a cartridge bore of said cartridge into a cylindrical medicament solvent charge chamber and a cylindrical medicament charge chamber,

said cartridge housing having means, fixedly attached thereto, for breaching said temporary sealing barrier,

said cartridge being suitable for separately storing a medicament solvent charge and a medicament charge in said medicament solvent charge chamber and said medicament charge chamber, respectively, said charges to be mixed to form a medicament to be expelled from said cartridge;

(C) a piston disposed within said first end of said cartridge and being slidably seated in said cartridge bore;

(D) a retractable needle housing assembly slidable in said cartridge housing;

(E) a retractable injection needle fixedly attached to said needle housing assembly and extending therethrough for injecting mixed medicament; and

(F) a puncturable cartridge end stopper rigidly attached to and sealing said second end of said cartridge.

25. The device of claim 24 wherein said cartridge housing further comprises

(G) a puncturable end cap, said end cap sealing said second end of said cartridge housing and having a needle guide disposed therein.

26. The device of claim 24 wherein said piston further comprises

(H) an operating shaft for operating said piston and said cartridge and for adapting said cartridge to other devices.

27. The device of claim 24 wherein said breachable temporary sealing barrier is so configured that said piston can pass sealably therethrough after said barrier is breached.

28. The device of claim 27 wherein said breachable temporary sealing barrier is provided with a cylindrical bore of substantially equal dimension to that of said cartridge bore so that said piston can pass sealably therethrough after said barrier is breached.

29. The device of claim 27 wherein said breachable temporary sealing barrier comprises a valve.

30. The device of claim 27 wherein said breachable temporary sealing barrier comprises a stopcock.

31. The device of claim 27 wherein said breachable temporary sealing barrier comprises a stopcock and operating cam, said operating cam being disposed within said cartridge chamber.

32. The device of claim 27 wherein said breachable temporary sealing barrier comprises a stopcock and operating cam, said operating cam being disposed on the outside of said cartridge.

33. The device of claim 27 wherein said breachable temporary sealing barrier comprises a membrane and seat therefor.

34. The device of claim 33 wherein said membrane seat is recessed into the wall of said cartridge cylinder bore a sufficient distance so that said cartridge piston slides sealably therethrough.

35. The device of claim 24 wherein said needle housing assembly is slidably disposed in said cylindrical bore of said cartridge housing and comprises

(A) a needle housing,

(B) an injection needle having a hollow shaft, an internal end, an internal shaft portion, an external end, an external shaft portion, first and second apertures, and a passageway extending through said hollow shaft and connecting said first and second apertures, said needle being rigidly attached to and extending through said needle housing,

said internal end of said needle extending through said needle assembly housing toward said puncturable cartridge end stopper,

said external end of said needle extending toward said puncturable end cap of said cartridge housing without protruding therefrom,

said needle being adapted to expel a medicament from said cartridge,

said housing having locking means for irreversibly locking said needle assembly housing to said cartridge when said needle cap assembly and said cartridge are a predetermined distance apart.

36. The device of claim 35 wherein said first injection needle aperture is disposed in said internal needle shaft portion an appropriate distance from said housing to receive fluid from a punctured medicament cartridge, and

said second injection needle aperture is disposed in said external needle end.

37. The device of claim 35 wherein said first injection needle aperture is disposed in said internal needle shaft end, and

said second injection needle aperture is disposed in said external needle end.

38. The device of claim 24 wherein said means fixedly attached to said cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises a pushrod.

39. The device of claim 24 wherein said means fixedly attached to said cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises

(A) a pushrod having an anchoring end and a puncturing end wherein said anchoring end is fixedly attached to said cartridge housing

said pushrod extending from said cartridge housing toward said cartridge puncturable end stopper, and

(B) a needle assembly housing having a pushrod aperture for freely guiding said pushrod therethrough so that said puncturing end of said pushrod resides in close proximity to and in alignment with said puncturable cartridge end stopper.

40. The device of claim 24 wherein said means fixedly attached to said cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises

(A) a pushrod having an anchoring end and a cam-engaging end wherein said anchoring end is fixedly attached to said cartridge housing,

said pushrod extending from said cartridge housing toward a cartridge stopcock operating cam, and

(B) a needle assembly housing having a pushrod aperture for freely guiding said pushrod therethrough so that said cam-engaging end of said pushrod resides in close proximity to and in alignment with said cartridge stopcock operating cam disposed between said cartridge and said cartridge housing.

41. The device of claim 24 wherein said temporary sealing barrier comprises a valve having an operating slot for engaging a spiral pushrod.

42. The device of claim 24 wherein said cartridge further comprises a mixing rotor adapted to be operated by a spiral pushrod.

43. The device of claims 41 or 42 wherein said means fixedly attached to said cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises

(A) a spiral pushrod having an anchoring end and a puncturing end suitable for engaging the operating slot of a rotor,

wherein said anchoring end is fixedly attached to said cartridge housing said pushrod extending from said cartridge housing toward said cartridge puncturable end stopper, and

(B) a needle assembly housing having a pushrod aperture for freely guiding said pushrod therethrough so that said puncturing end of said pushrod resides in close proximity to and in alignment with said puncturable cartridge end stopper.

44. The device of claim 24 wherein said breachable temporary sealing barrier comprises a plug.

45. The device of claim 43 wherein said barrier comprises a truncated cone and seat therefor.

46. The device of claim 43 wherein said barrier comprises a truncated pyramid and seat therefor.

47. The device of claim 43 wherein said barrier comprises a ball and seat therefor.

48. The device of claim 43 wherein said barrier comprises a flap.

49. The device of claim 43 wherein said barrier comprises a trapdoor.

50. The device of claim 24 wherein said breachable temporary sealing barrier comprises a membrane.

51. The device of claim 49 wherein said membrane comprises a synthetic polymer.

52. The device of claim 49 wherein said polymer is polystyrene.

53. The device of claim 49 wherein said polymer is polyethylene.

54. The device of claim 49 wherein said membrane comprises rubber.

55. The device of claim 24 wherein said breachable temporary sealing barrier comprises a disk.

56. The device of claim 55 wherein said disk is circular.

57. The device of claim 55 wherein said disk is ovoid.

58. The device of claim 55 wherein said disk is polygonal.

59. The device of claim 55 wherein said disk comprises a synthetic polymer.

60. The device of claim 55 wherein said polymer is polystyrene.

61. The device of claim 55 wherein said polymer is polyethylene.

62. The device of claim 55 wherein said disk comprises polyethylene.

63. The device of claim 55 wherein said disk comprises rubber.

64. The device of claim 24 wherein said breachable temporary sealing barrier comprises a valve.

65. The device of claim 64 wherein said valve is a rotary valve.

66. The device of claim 64 wherein said valve is an iris valve.

67. The device of claim 64 wherein said valve is a stopcock.

68. The device of claim 64 wherein said valve is a ball valve.

69. The device of claim 68 wherein said ball valve has an aperture suitable for the sealable passage therethrough of a piston.

70. The device of claim 64 wherein said valve is a gate valve.

71. A mixing syringe for two-component medicaments comprising:

(A) a cartridge housing having a first end and a second end, said cartridge housing having a substantially cylindrical cartridge housing bore; (B) a slidable cartridge disposed in said cartridge housing bore and having a first end, a second end, and a temporary sealing barrier disposed between said first and second ends and separating a cartridge bore of said cartridge into a cylindrical medicament solvent charge chamber and a cylindrical medicament charge chamber,

said cartridge housing having means, fixedly attached thereto, for breaching said temporary sealing barrier,

said cartridge being suitable for separately storing a medicament solvent charge and a medicament charge in said medicament solvent charge chamber and said medicament charge chamber, respectively, said charges to be mixed to form a medicament to be expelled from said cartridge;

(C) a piston disposed within said first end of said cartridge and being slidably seated in said cartridge bore;

(D) a needle housing assembly rigidly attached to said cartridge and contained wholly within said cartridge housing;

(E) an injection needle which is containable wholly within said cartridge housing, which can be extended to a position in which at least a portion of said needle extends outside of said cartridge housing,

said needle being fixedly attached to said needle housing assembly and extending therethrough for injecting mixed medicament;

(F) a puncturable end cap, said end cap sealing said second end of said cartridge housing; and

(G) means for retracting said needle to reside completely within said cartridge housing after the expulsion of said medicament from said syringe.



72. The device of claim 71 wherein said breachable temporary sealing barrier is so configured that said piston can pass sealably therethrough after said barrier is breached.

73. The device of claim 72 wherein said breachable temporary sealing barrier is provided with a cylindrical bore of substantially equal dimension to that of said cartridge bore so that said piston can pass sealably therethrough after said barrier is breached.

74. The device of claim 71 wherein said temporary sealing barrier comprises a rotating valve disposed through said cartridge and a valve operating cam disposed on the exterior of said cartridge,

said valve operating cam being configured to be operated by a pushrod.

75. The device of claim 71 wherein said means fixedly attached to said cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises

a valve cam operating pushrod.

76. The device of claim 74 wherein said valve cam operating pushrod is integral to said housing.

77. The device of claims 24 or 71 wherein said means fixedly attached to said cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises

(A) an electronically actuated pushrod contained within said cartridge; and

(B) an electronic pushrod actuator contained within said cartridge housing.

78. The device of claims 24 or 71 wherein said means fixedly attached to said cartridge housing for breaching a temporary sealing barrier between chambers of said slidable cartridge comprises

(A) a magnetically actuated pushrod contained within said cartridge; and

(B) a magnetic pushrod actuator contained within said cartridge housing.

79. A mixing cartridge for two-component medicaments comprising:

(A) a cartridge having a first end, a second end, and a breachable temporary sealing barrier dividing a cylindrical cartridge bore of said cartridge into a medicament solvent charge chamber and a medicament charge chamber,

said breachable temporary sealing barrier being so configured that a piston can pass sealably therethrough after said barrier is breached,

said cartridge being suitable for separately storing a medicament solvent charge and a medicament charge in said medicament solvent charge chamber and said medicament charge chamber, respectively, said charges to be mixed to form a medicament to be expelled from said cartridge,

said cartridge second end being adaptable for receiving an injection needle;

(B) a piston disposed within said first end of said cartridge and being slidably seated in said cartridge bore; and

(C) a puncturable cartridge end stopper rigidly attached to and sealing said second end of said cartridge.

80. The device of claim 79 wherein said piston further comprises

(D) an operating shaft for operating said piston and for adapting said cartridge to other devices.

81. The device of claim 79 wherein said breachable temporary sealing barrier is provided with a cylindrical bore of substantially equal dimension to that of said cartridge bore so that said piston can pass sealably therethrough after said barrier is breached.

82. The device of claim 81 wherein said breachable temporary sealing barrier comprises a valve.

83. The device of claim 81 wherein said breachable temporary sealing barrier comprises a stopcock.

84. The device of claim 81 wherein said breachable temporary sealing barrier comprises a membrane and seat therefor.

85. The device of claim 84 wherein said membrane seat is recessed into the wall of said cartridge cylinder bore.

86. The device of claim 79 wherein said cartridge further comprises

(D) an injection needle fixedly attached to said second end of said cartridge and extending sufficiently through said puncturable cartridge end stopper to permit injection of said mixed medicament.

87. The device of claim 79 wherein said cartridge second end further comprises means for securely and reversibly receiving an injection needle.

88. The device of claim 87 wherein said means comprises indentations on the outside surface of said

cartridge second end said indentations being adaptable for receipt of a needle assembly housing.

89. The device of claim 87 wherein said means comprises at least one groove on the outside surface of said cartridge second end said groove being adaptable for receipt of a needle assembly housing.

90. The device of claim 89 wherein said groove is formed by a narrowing transition between said puncturable cartridge end stopper and said cartridge.

91. A needle housing assembly for use with a necked medicament container having a puncturable end stopper comprising:

(A) a needle housing;

(B) locking means, disposed in said needle housing, for locking said housing to said necked medicament container when said needle housing assembly and said necked cartridge become a predetermined distance apart upon relative movement between said necked medicament container and said needle housing; and

(C) an injection needle having a hollow shaft, an internal end, an internal shaft portion, an external end, an external shaft portion, first and second apertures, and a passageway extending through said hollow shaft and connecting said first and second apertures, said needle being rigidly attached to and extending through said needle housing,

said internal end and internal shaft portion of said needle being adapted to puncture a necked medicament container, and

said external end and external shaft portion of said needle being adapted to expel a medicament out of said needle housing assembly.

92. The device of claim 68 wherein said means for locking said housing to a necked medicament container comprises protrusions which are disposed in said housing and which are adapted to securely engage the neck and head portions of a medicament container.

93. The device of claim 92 wherein said means for locking said housing to a necked medicament container comprises at least one flange disposed in said housing for securely engaging the neck and head portions of a medicament container.

94. The device of claim 93 wherein said means for locking said housing to a necked medicament container comprises a multiplicity of flanges, disposed in said housing, for securely engaging the neck and head portions of a medicament container.

95. The device of claim 91 wherein said injection needle further comprises a pushrod for breaching a temporary sealing barrier between chambers of a medicament cartridge.

96. The device of claims 91 or 72 wherein said first injection needle aperture is disposed in said internal needle shaft portion an appropriate distance from said housing to receive fluid from a punctured medicament cartridge, and

said second injection needle aperture is disposed in said external needle end.

97. The device of claims 91 or 95 wherein said first injection needle aperture is disposed in said internal needle shaft end, and

said second injection needle aperture is disposed in said external needle end.

98. The device of claim 91 further comprising means, fixedly attached to said needle housing, for breaching a temporary sealing barrier between the chambers of a two-chambered medicament container.

99. The device of claim 91 further comprising means, fixedly attached to said needle housing, for sterilely enclosing said injection needle until use.

100. The device of claim 99 wherein said means further comprises removable sheaths disposed around said internal and said external needle ends and portions.

101. The device of claim 91 further comprising means, fixedly attached to said needle housing, for sterilely enclosing said injection needle during use.

102. The device of claim 101 wherein said means further comprises puncturable sheaths.

103. The device of claim 101 wherein said means further comprises compressible sheaths disposed around said internal and said external needle ends and portions.

104. The device of claim 102 wherein said sheaths are pleated.

105. The device of claim 91 wherein said locking means is configured to reversibly lock said housing to said necked medicament container.

106. The device of claim 91 wherein said locking means is configured to irreversibly lock said housing to said necked medicament container.

107. A mixing syringe for two-component medicaments comprising:

(A) a cartridge housing having a first end and a second end, said cartridge housing having a substantially cylindrical cartridge housing bore;

(B) a slidable cartridge disposed in said cartridge housing bore and having a first end, a second end, and a temporary sealing barrier disposed between said first and second ends and separating a cartridge bore of said cartridge into a cylindrical medicament solvent charge chamber and a cylindrical medicament charge chamber,

said cartridge being suitable for separately storing a medicament solvent charge and a medicament charge in said medicament solvent charge chamber and said medicament charge chamber, respectively, said charges to be mixed to form a medicament to be expelled from said cartridge;

(C) a piston disposed within said first end of said cartridge and being slidably seated in said cartridge bore;

(D) a retractable needle housing assembly slidable in said cartridge housing said needle housing having means, fixedly attached thereto, for breaching said temporary sealing barrier;

(E) a retractable injection needle having a hollow shaft, an internal end, an internal shaft portion, an external end, an external shaft portion, first and second apertures, and a passageway extending through said hollow shaft and connecting said first and second apertures, said needle being rigidly attached to and extending through said needle housing,

said internal end and internal shaft portion of said needle being adapted to puncture said cartridge, and

said external end and external shaft portion of said needle being adapted to expel a medicament out of said needle housing assembly,

said first injection needle aperture being disposed in said internal needle shaft portion and

appropriate distance from said housing to receive fluid from a punctured medicament cartridge, and

said second injection needle aperture being disposed in said external needle end;

(F) a puncturable cartridge end stopper rigidly attached to and sealing said second end of said cartridge.

108. The device of claim 107 wherein said cartridge further comprises

(G) a puncturable end cap, said end cap sealing said second end of said cartridge housing and having a needle guide disposed therein.

109. The device of claim 107 wherein said piston further comprises

(H) a piston shaft for operating said piston and said cartridge and for adapting said cartridge to other devices.

110. The device of claim 107 wherein said internal end of said injection needle comprises said means for breaching said temporary sealing barrier.

111. The device of claim 107 wherein said breachable temporary sealing barrier is so configured that said piston can pass sealably therethrough after said barrier is breached.

112. The device of claim 110 wherein said breachable temporary sealing barrier is provided with a cylindrical bore of substantially equal dimension to that of said cartridge bore so that said piston can pass sealably therethrough after said barrier is breached.

113. The device of claim 110 wherein said breachable temporary sealing barrier comprises a valve.



114. The device of claim 110 wherein said breachable temporary sealing barrier comprises a stopcock.

115. The device of claim 110 wherein said breachable temporary sealing barrier comprises a stopcock and operating cam, said operating cam being disposed within said cartridge chamber.

116. The device of claim 110 wherein said breachable temporary sealing barrier comprises a stopcock and operating cam, said operating cam being disposed on the outside of said cartridge.

117. The device of claim 110 wherein said breachable temporary sealing barrier comprises a membrane and seat therefor.

118. The device of claim 116 wherein said membrane seat is recessed into the wall of said cartridge cylinder bore a sufficient distance so that said cartridge piston slides sealably therethrough.

119. The device of claim 109 wherein said piston is puncturable by said injection needle internal end and said piston shaft is chambered so that said needle internal end can penetrate said piston and said piston shaft chamber to permit said piston to pass sealably through said temporary barrier.

120. The device of claims 24, 71, 79 or 107 wherein said cartridge further comprises one or more medically active substances.

121. The device of claim 120 wherein said medically active substances are selected from the group comprising glucagon, human growth hormone, papaverine, morphine.

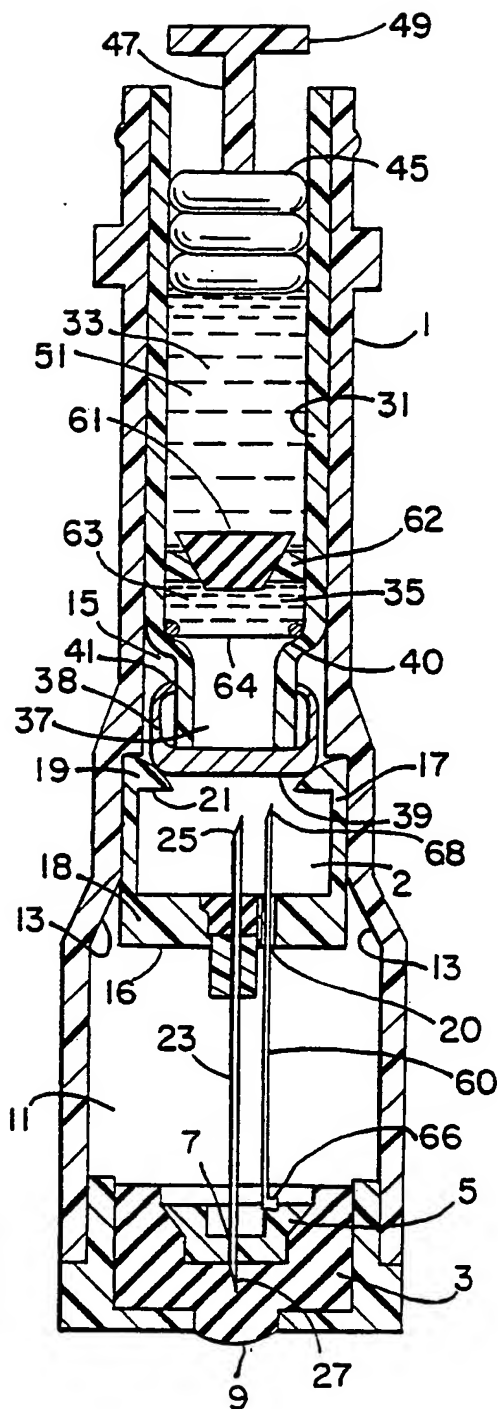


FIG. 1

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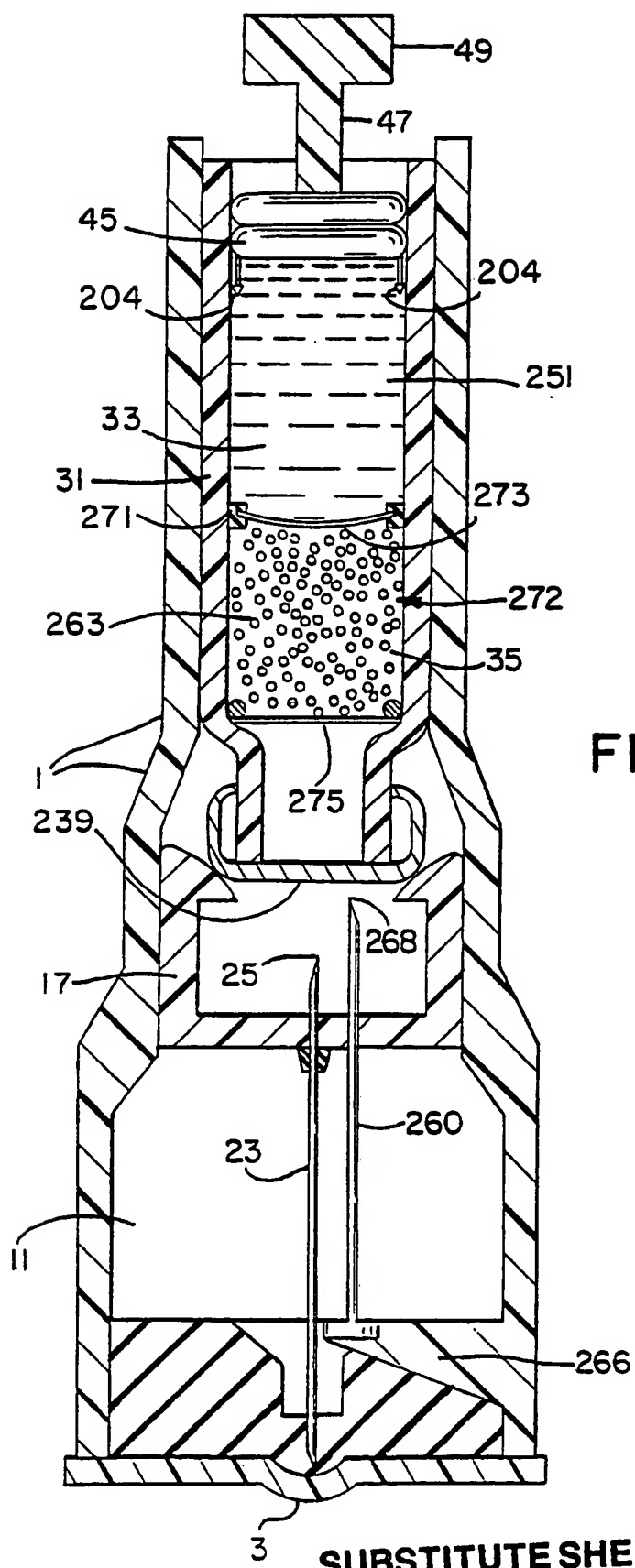


FIG. 2(a)

FIG. 2(b)

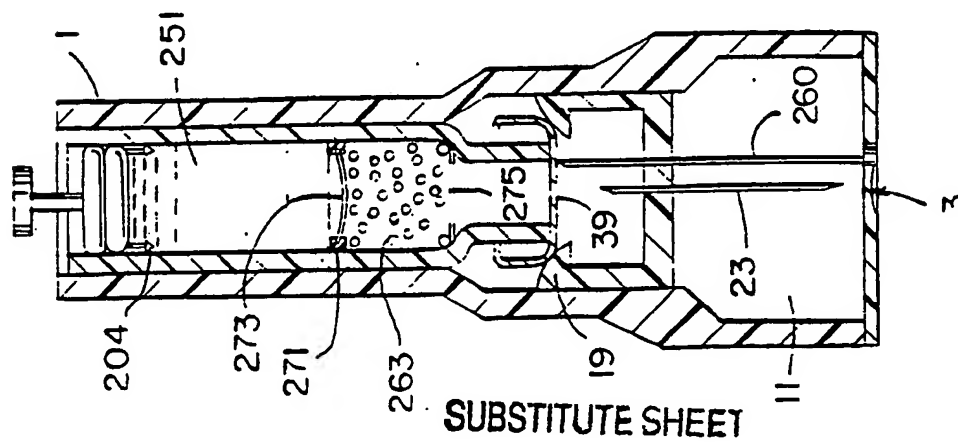


FIG. 2(c)

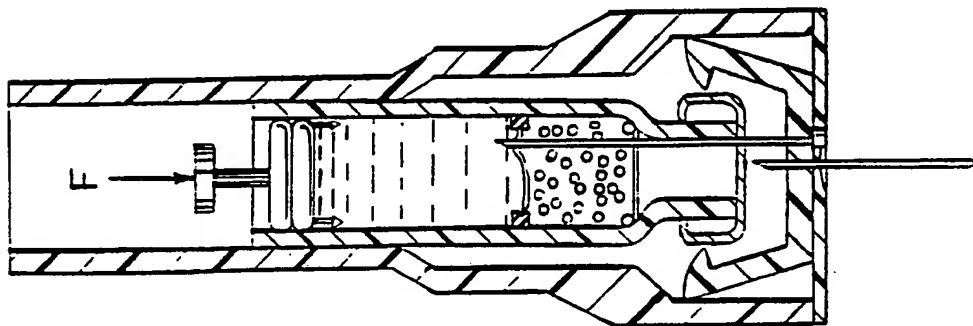


FIG. 2(d)

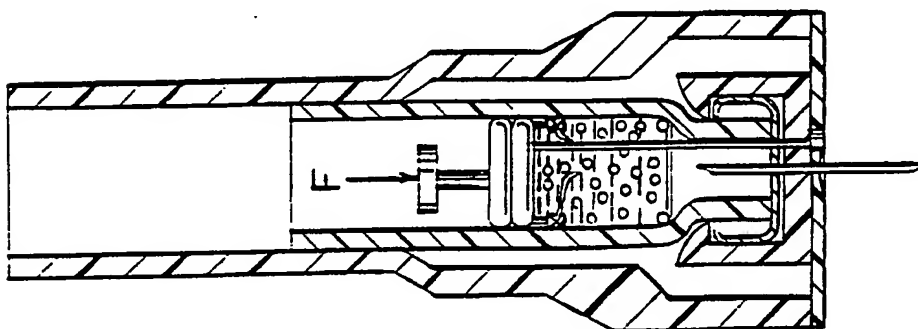
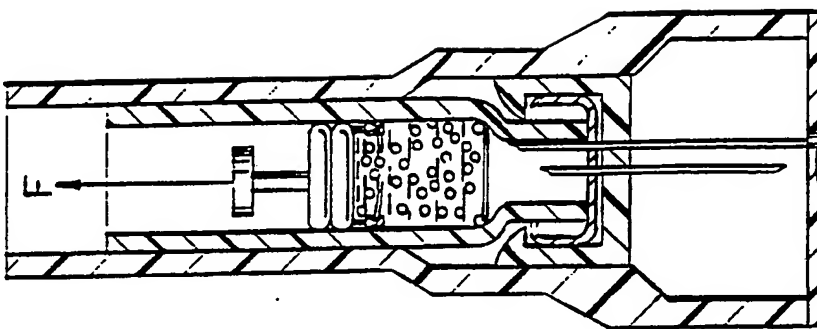


FIG. 2(e)



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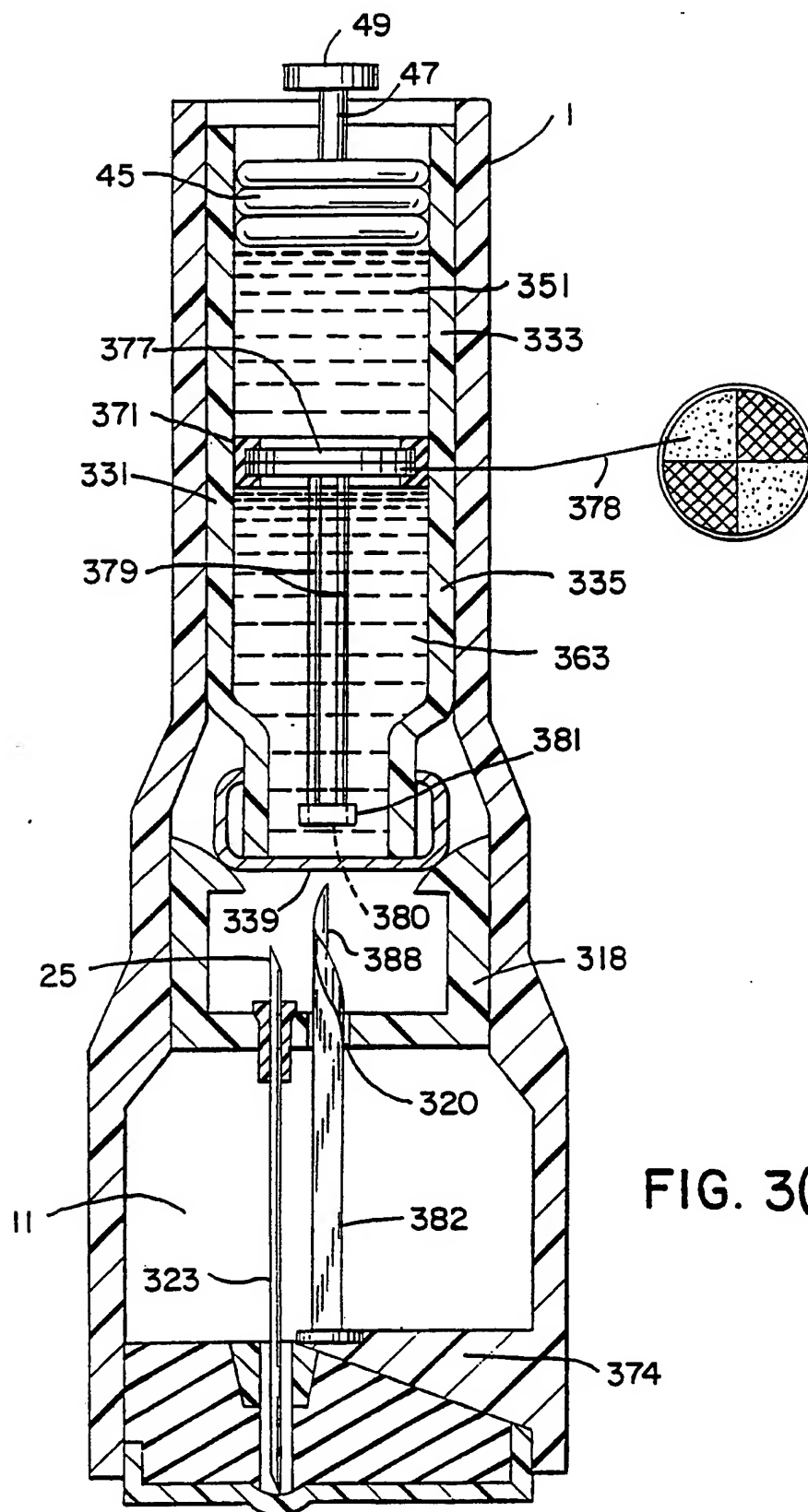


FIG. 3(a)

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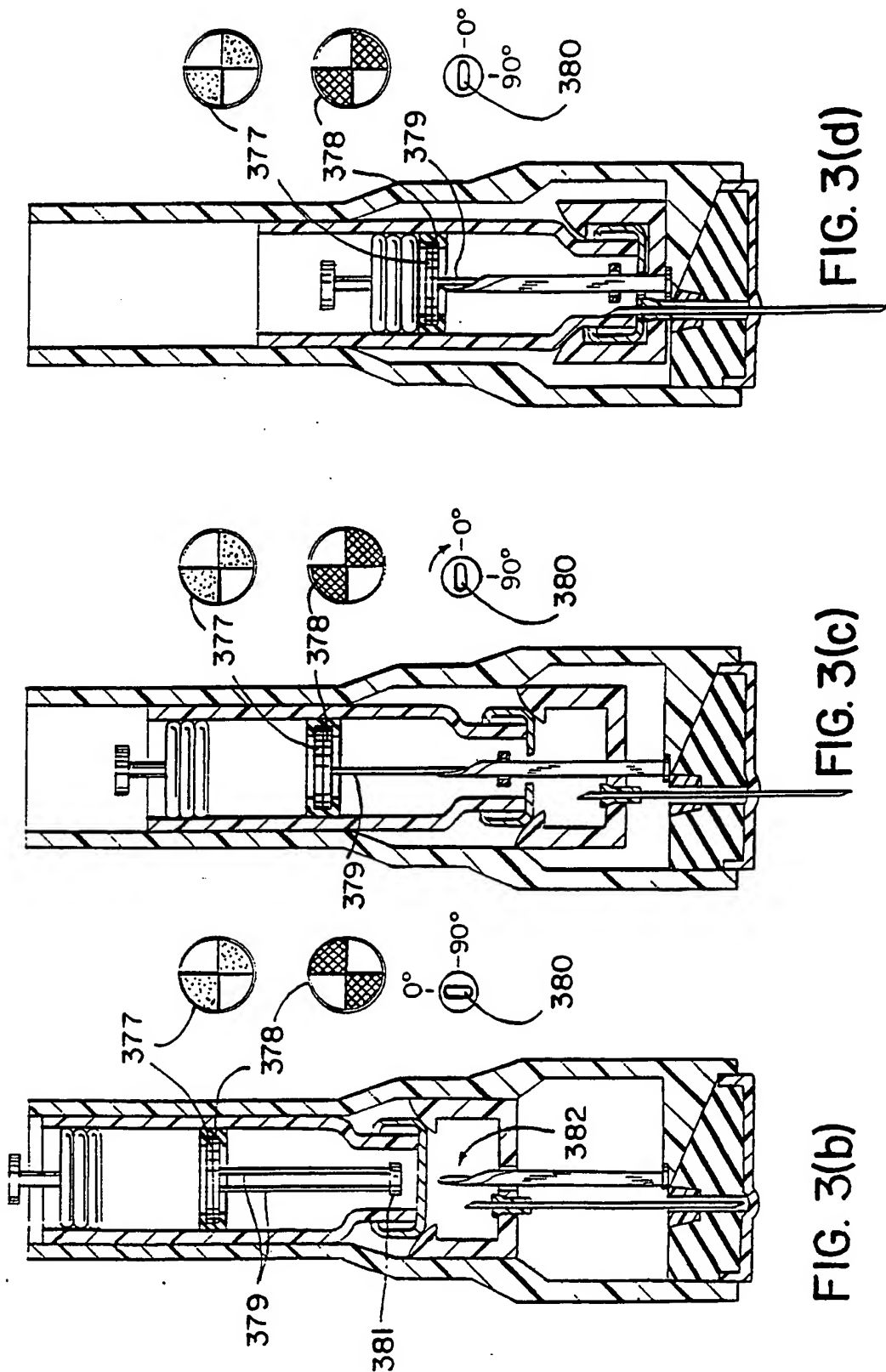
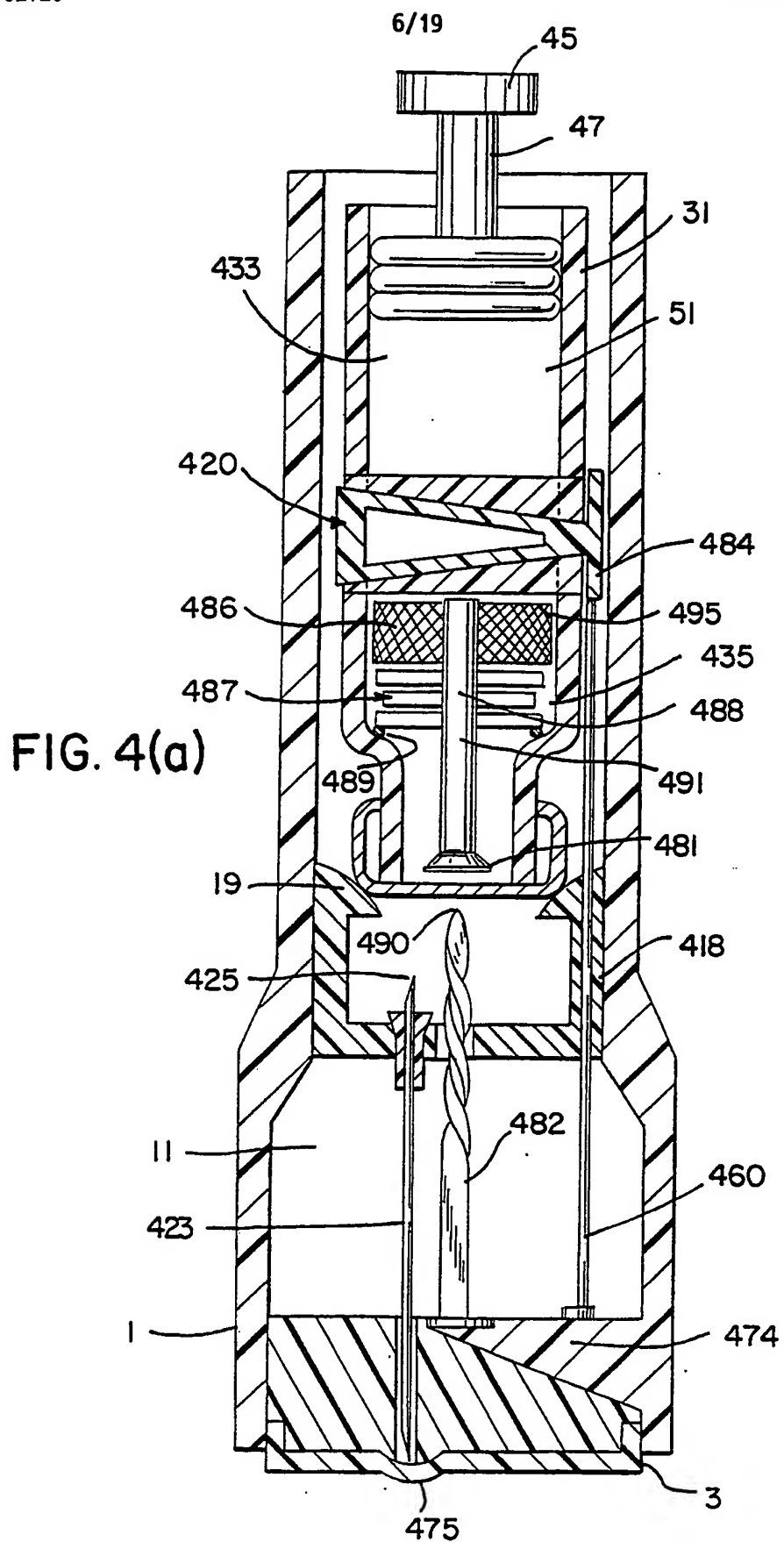


FIG. 3(d)

FIG. 3(c)

FIG. 3(b)



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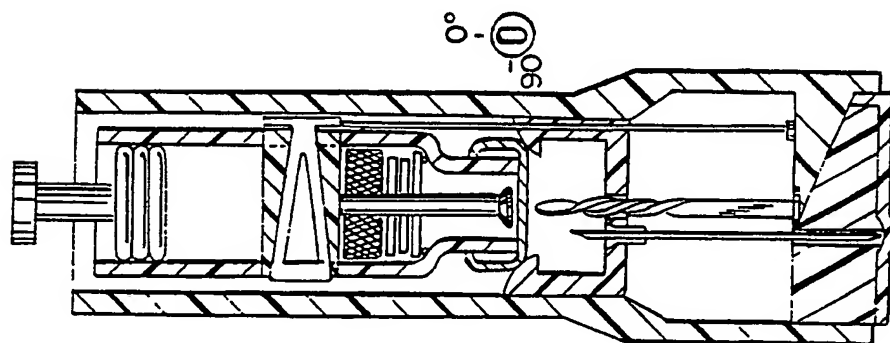


FIG. 4(b)

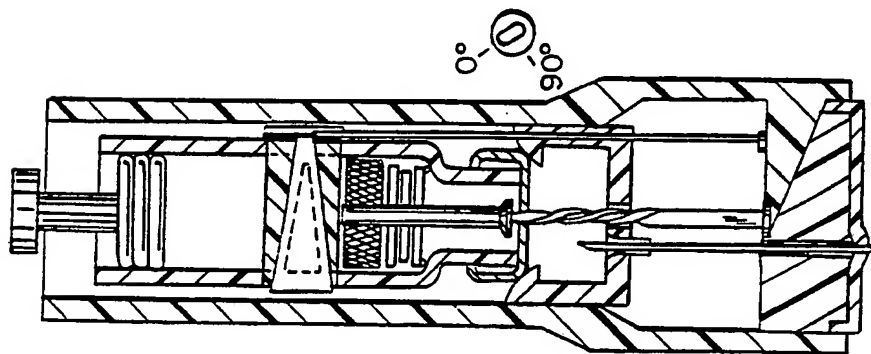


FIG. 4(c)

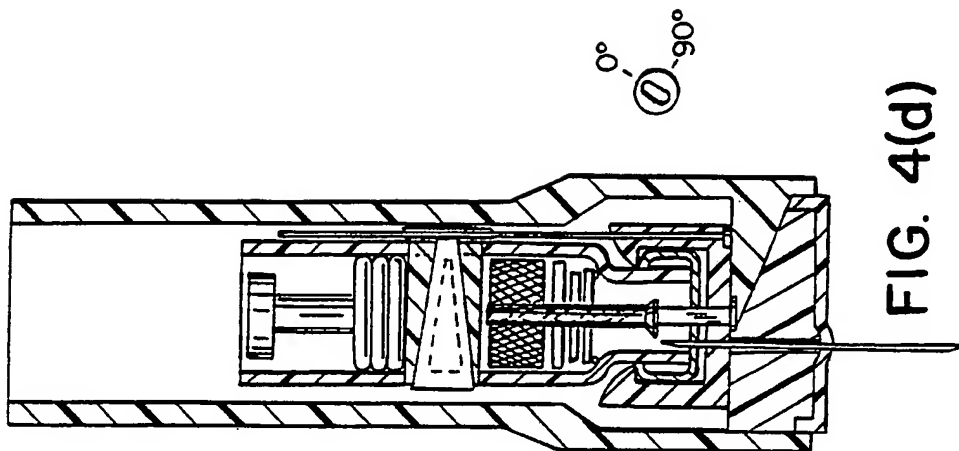


FIG. 4(d)



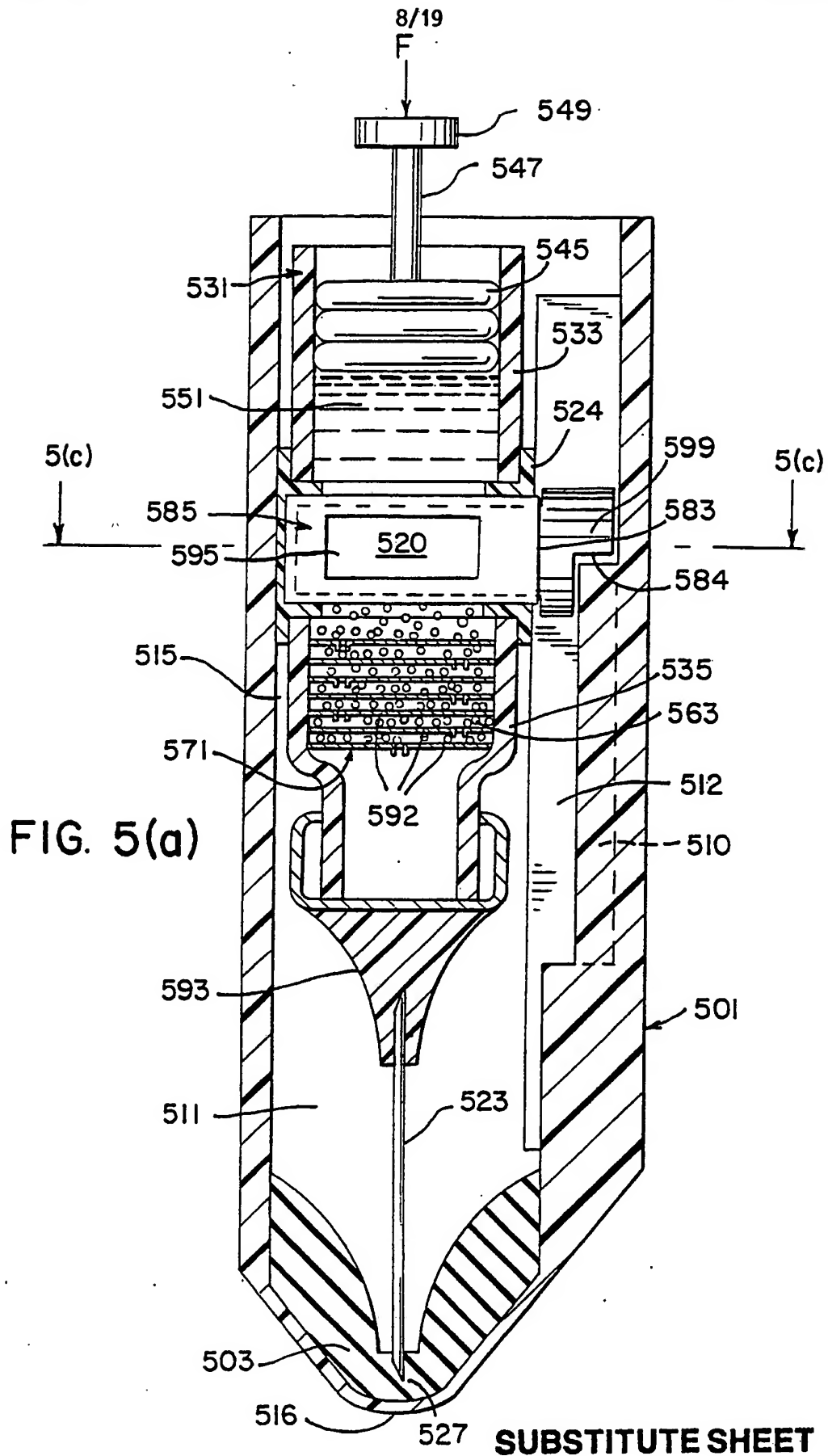


FIG. 5(b)

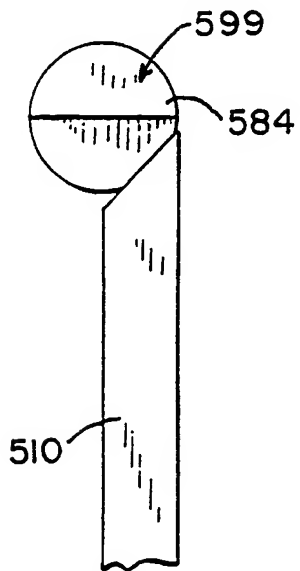


FIG. 5(c)

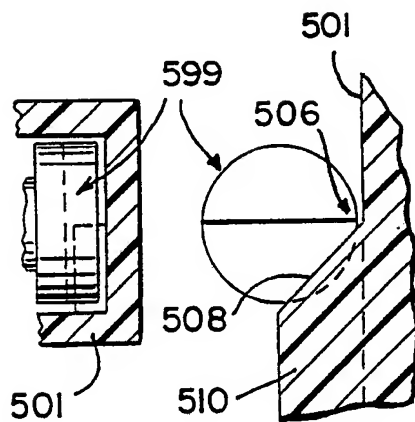
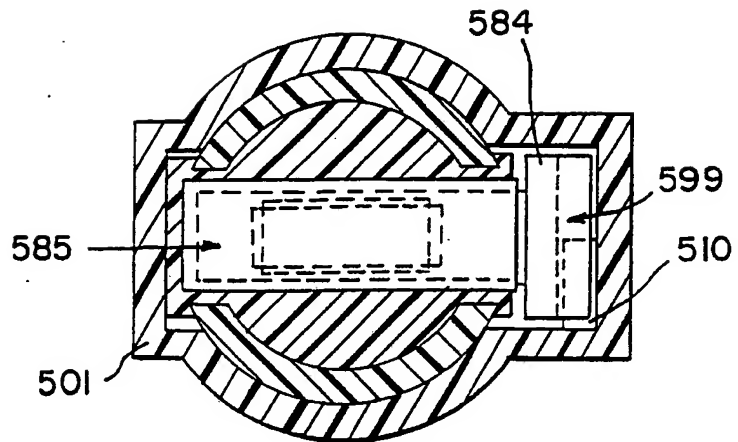
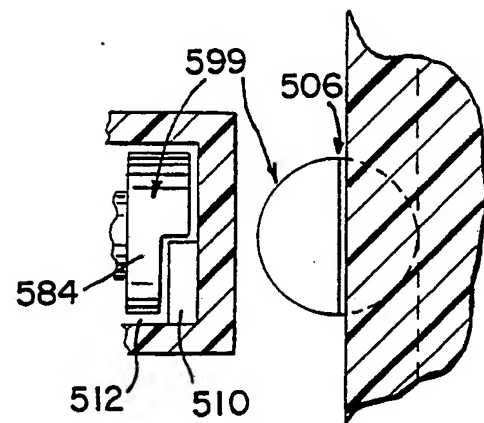
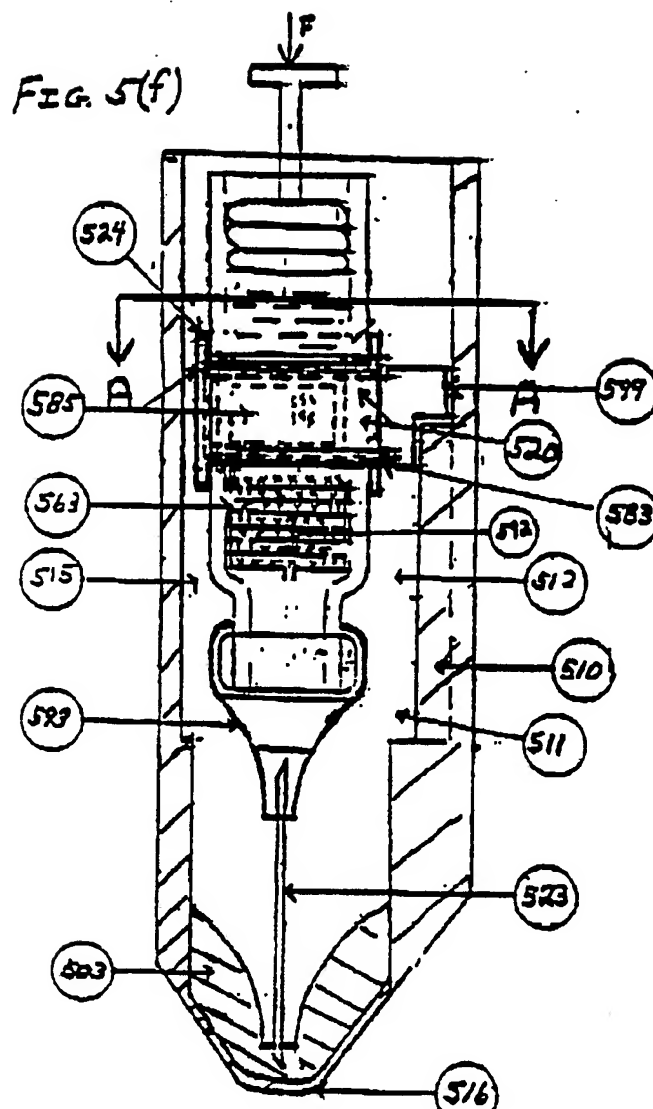


FIG. 5(d)

FIG. 5(e)





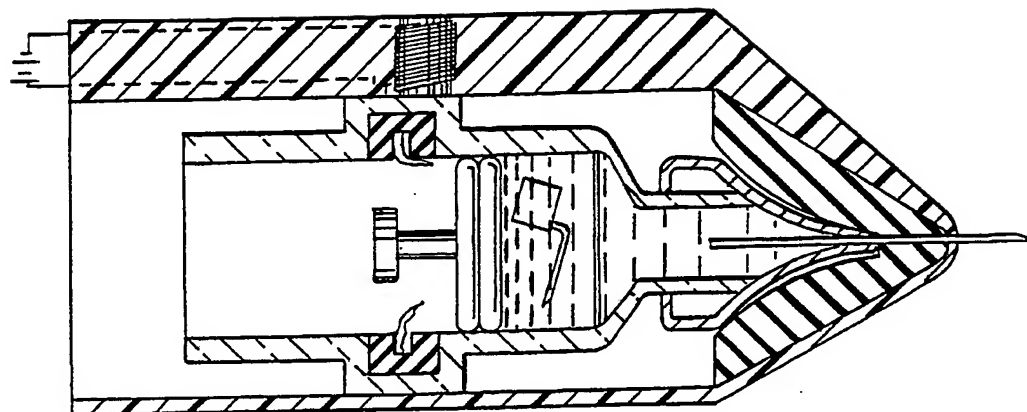


FIG. 6(c)

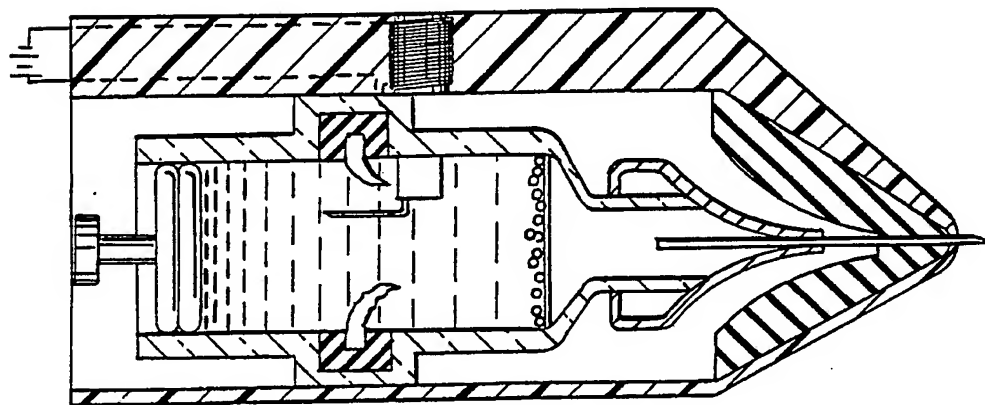


FIG. 6(b)

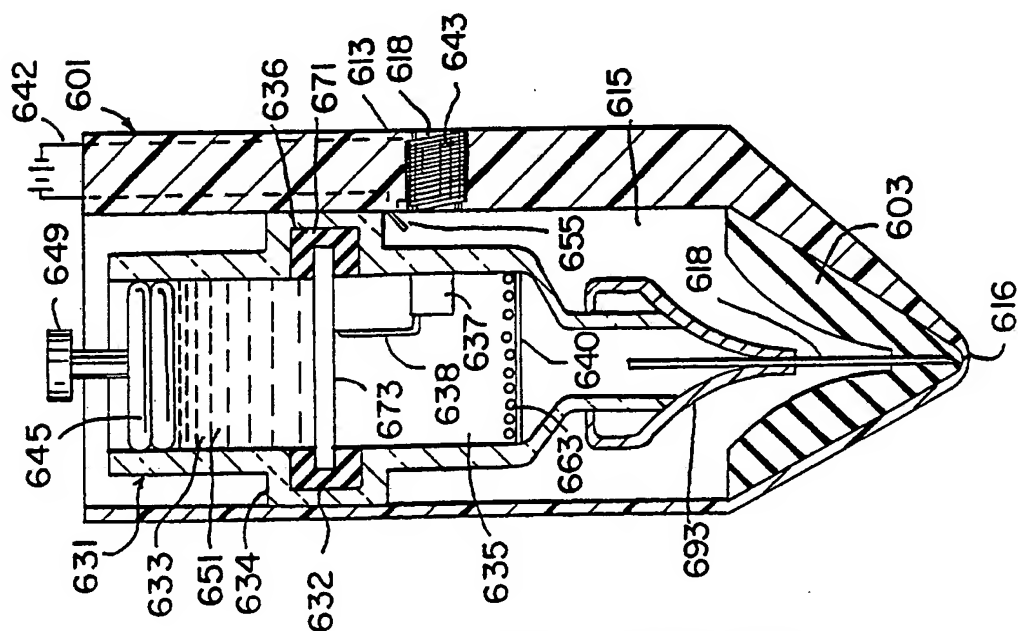


FIG. 6(a)

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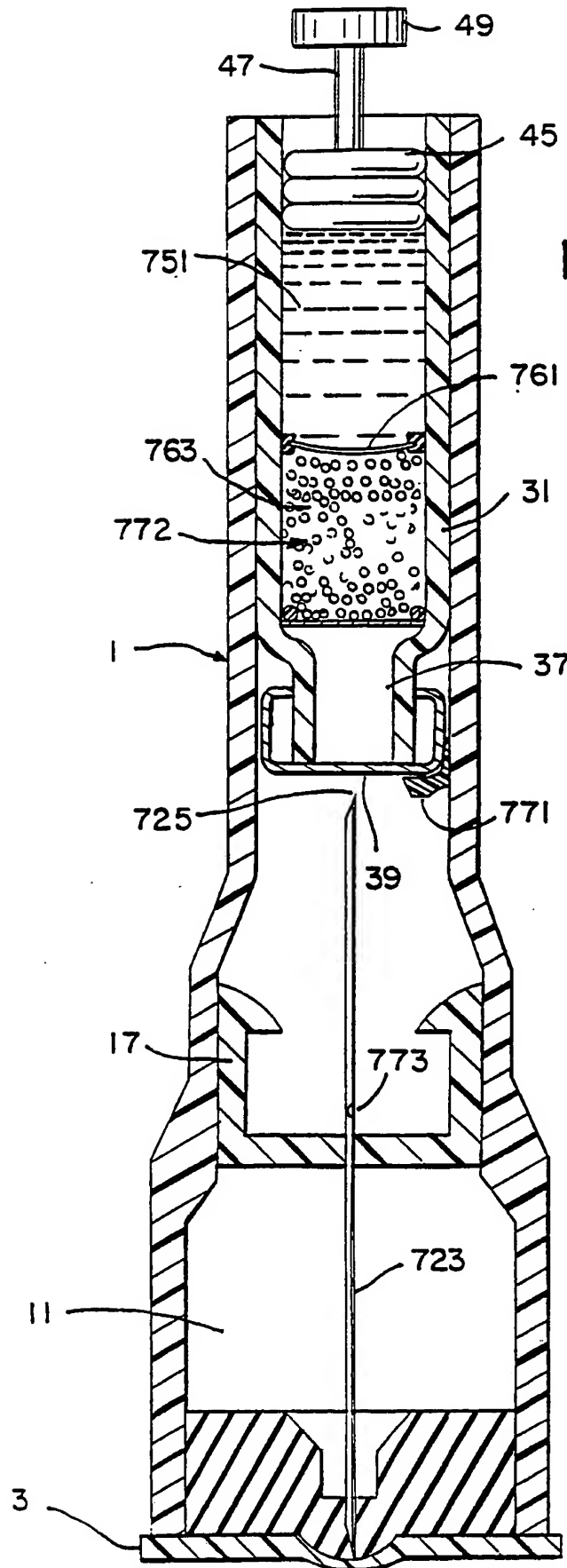


FIG. 7

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FIG. 8(a)

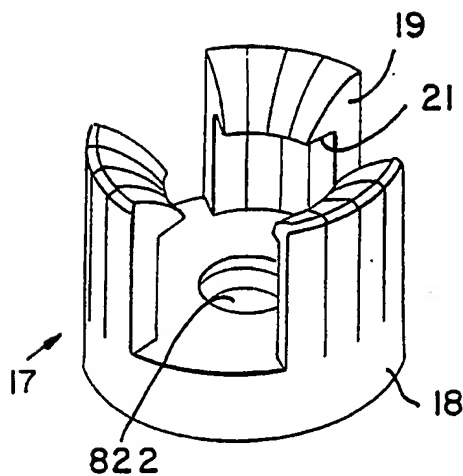


FIG. 8(b)

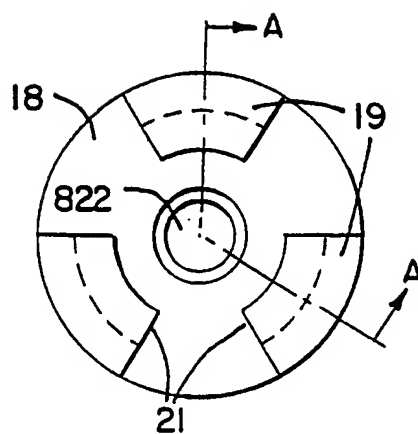


FIG. 8(c)

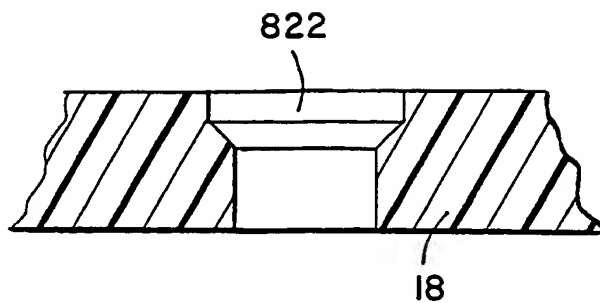
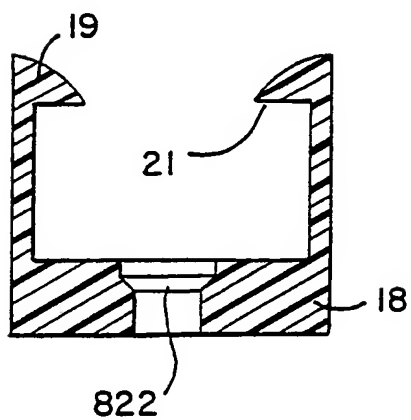


FIG. 8(d)

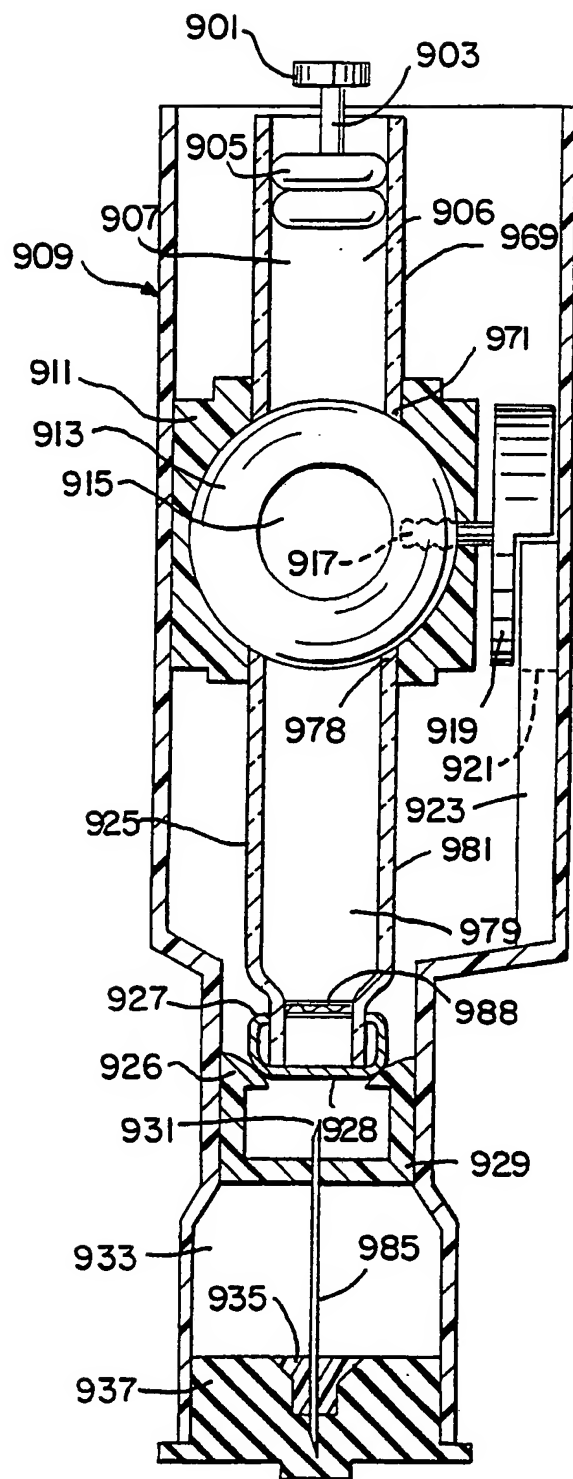


FIG. 9(a)

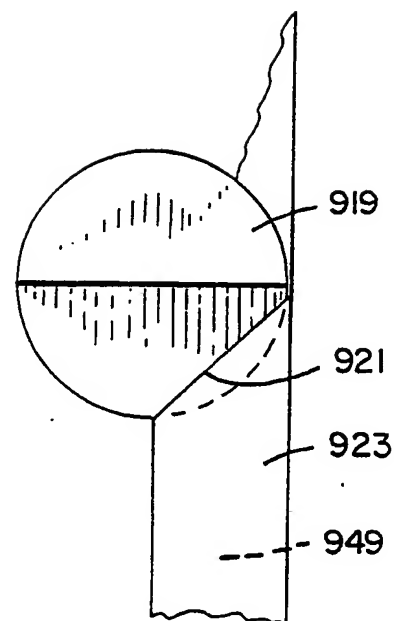
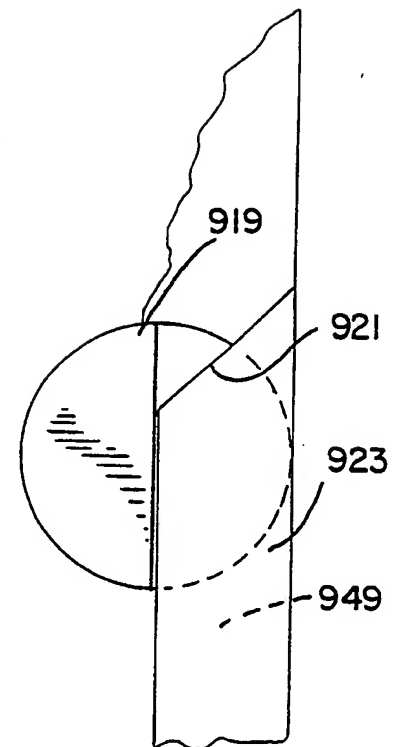
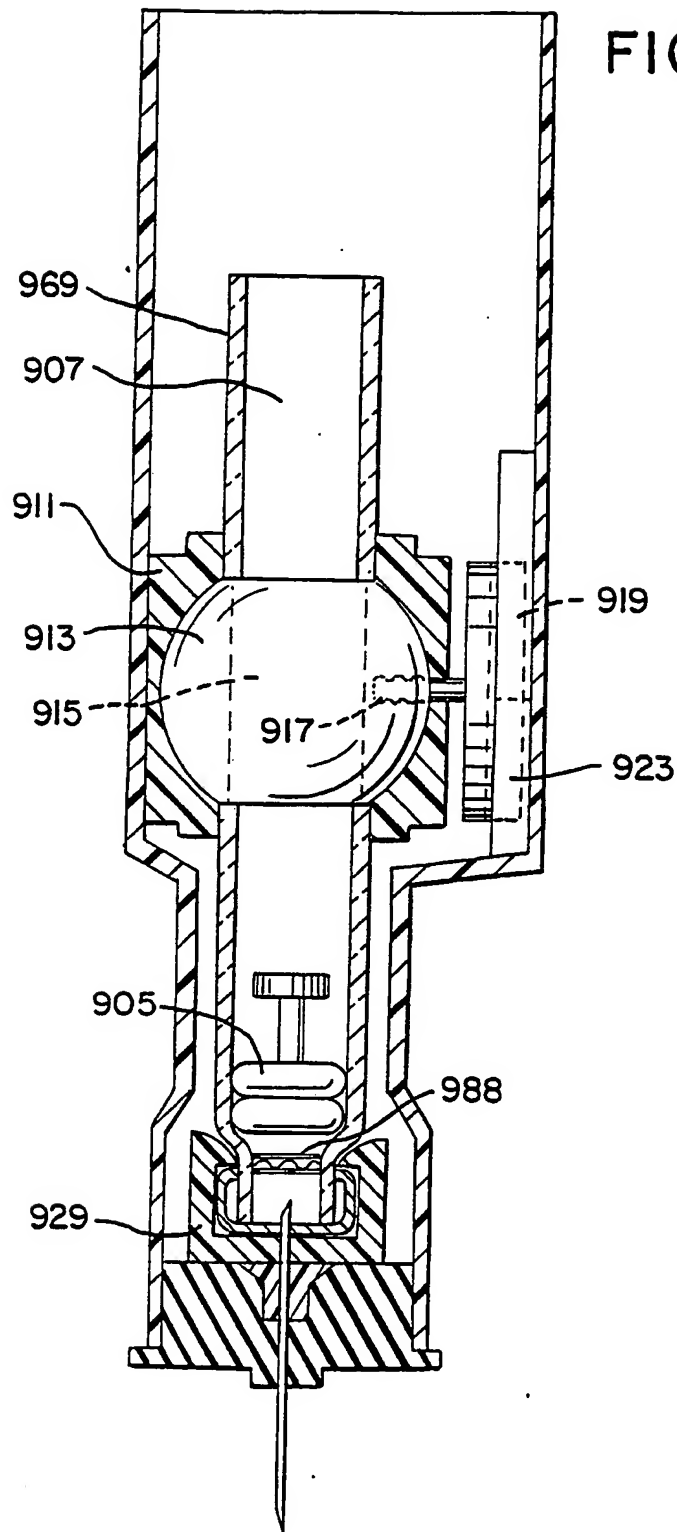


FIG. 9(b)





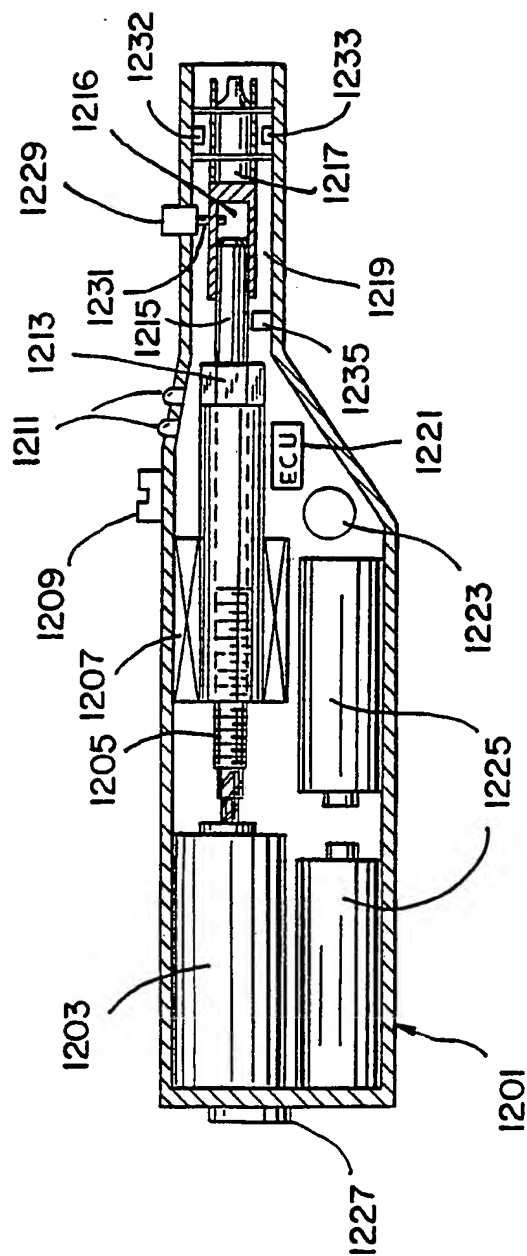


FIG. 10

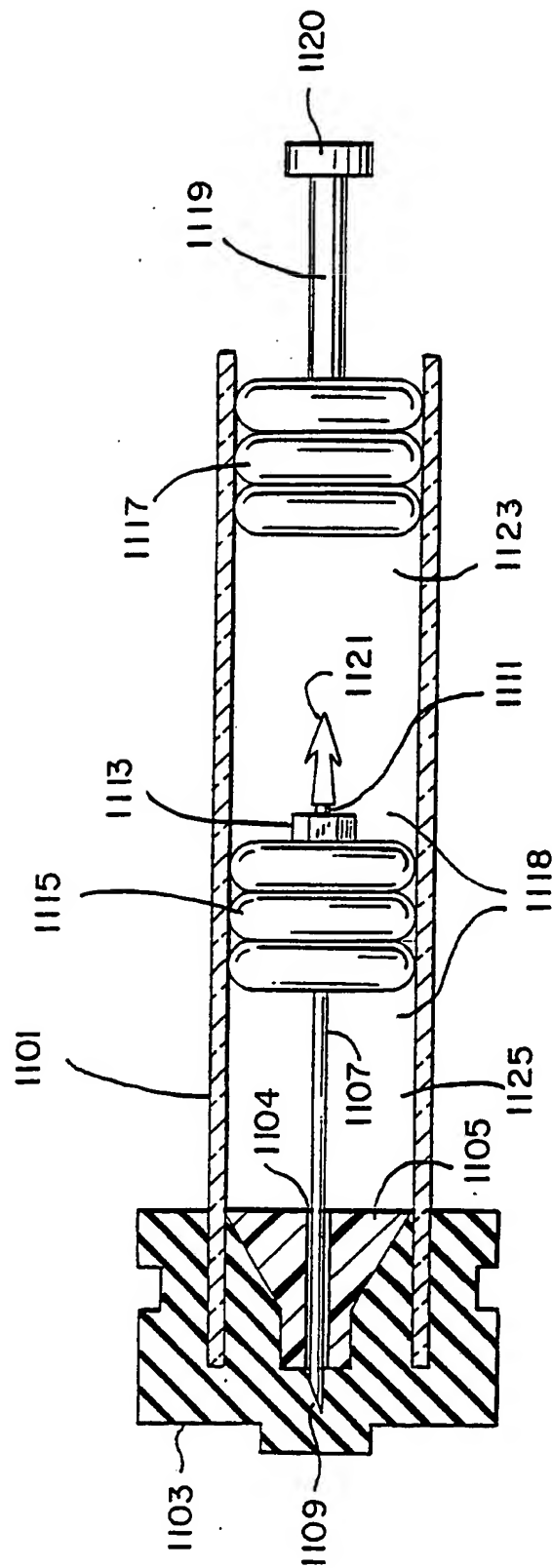
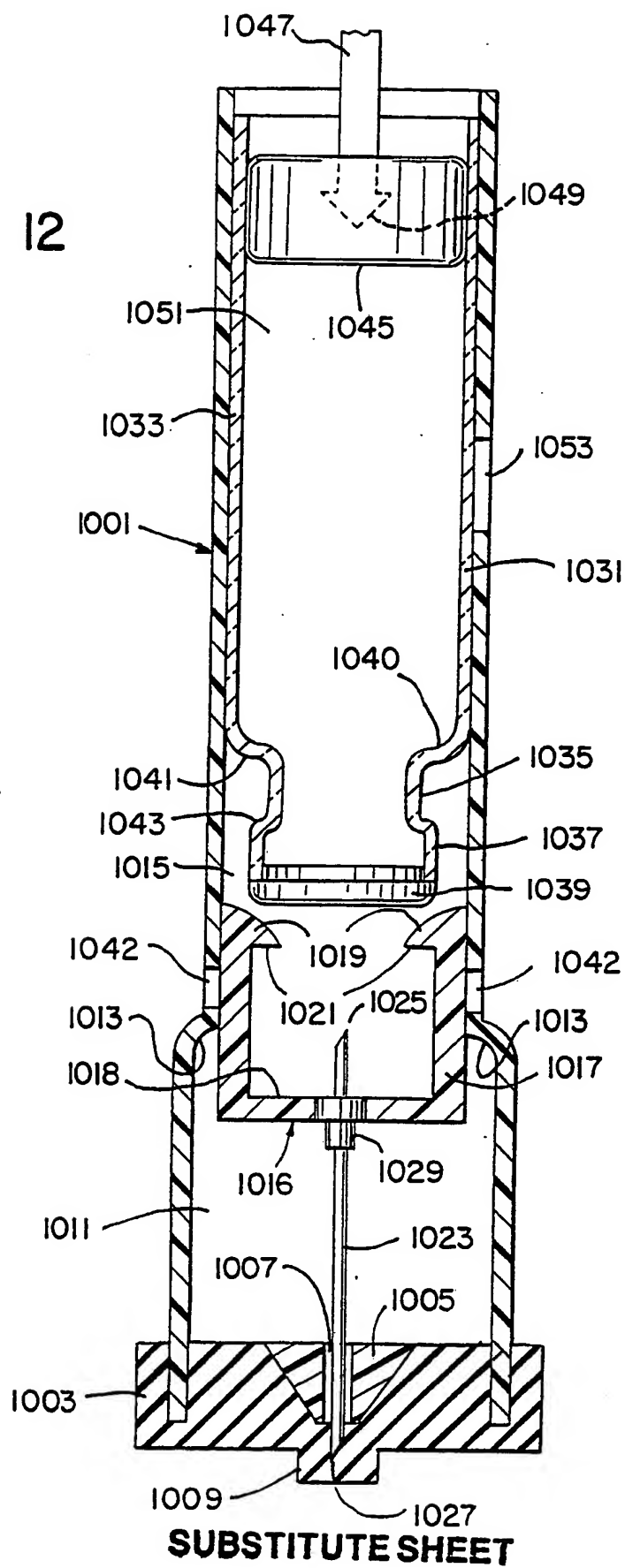


FIG. 11

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FIG. 12



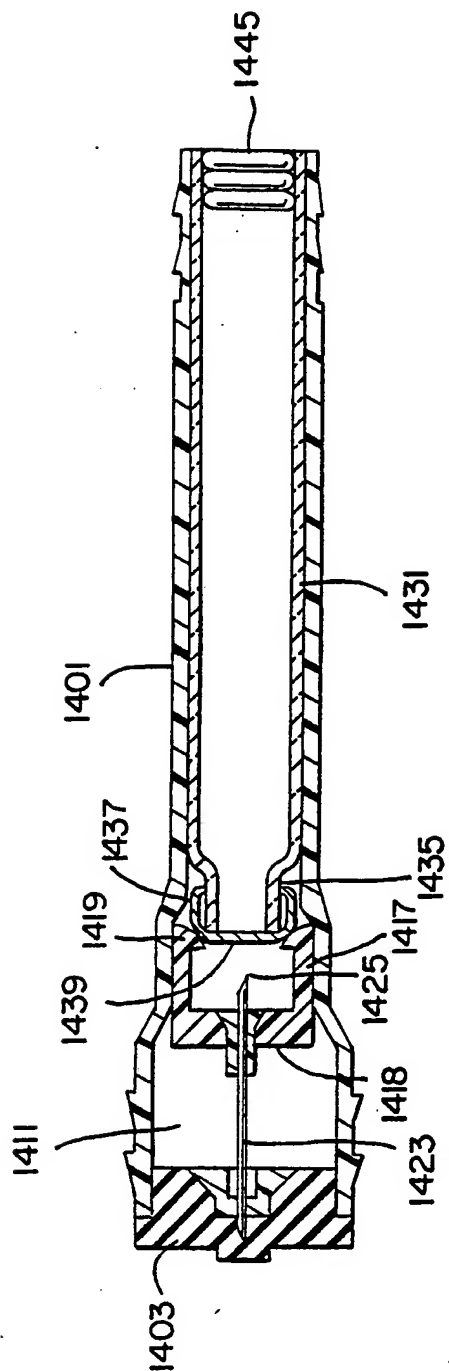


FIG. 13

## INTERNATIONAL SEARCH REPORT

PCT/US92/06587

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) :A61M 5/00

US CL :604/232

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 604/89, 91, 187, 195, 196, 198, 207, 218, 233-237; 603/232

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A, P	US, A, 5,094,148 (Haber et al.) 10 March 1992 See entire document	
<u>X</u> Y	US, A, 4,936,833 (Sams) 26 June 1990 See entire document.	<u>6-9, 13-16, 91,</u> <u>96-97, 99, 101,</u> <u>105</u> 10-12, 17, 18, 100, 102-103, 106
A, P	US, A, 5,114,406 (Gabriel et al.) 19 May 1992 See entire document.	

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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*O* document referring to an oral disclosure, use, exhibition or other means		
*P* document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 08 JANUARY 1993	Date of mailing of the international search report 15 JAN 1993
Name and mailing address of the ISA/ Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer RONALD STRIGHT, JR.
Facsimile No. NOT APPLICABLE	Telephone No. (703) 308-2113

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US92/06587

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
<u>X</u> Y	US, A, 4,968,299 (Ahlstrand et al.) 06 November 1990 See entire document.	<u>105, 107, 109,</u> <u>110, 113-114,</u> <u>120, 24, 26, 35-</u> <u>38, 44, 50, 55,</u> <u>56-57, 59-64, 67,</u> <u>91, 95-99</u> 1-5, 19-20, 25, 58, 66, 71, 75- 76, 100-104, 106, 108, 121
A, P	US, A, 5,092,842 (Bechtold et al.) 03 March 1992 See entire document.	
A, P	US, A, 5,112,317 (Michel) 12 May 1992 See entire document.	
A	US, A, 4,755,169 (Sarnoff et al.) 05 July 1988. See entire document.	

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